

# Twelfth SEMIANNUAL REPORT TO DECEMBER 31, 1964 CONGRESS

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To the Congress of the United States:

This report to the Congress describes a six-month period of impressive accomplishment by the National Aeronautics and Space Administration.

In a larger sense, however, this report describes America on the move.

The story of man's advancement through the ages is the story of man's victory over the forces of nature. The health and comfort he enjoys, the leisure he possesses, and the abundance of the food he eats are all the result of his unending determination to probe the secrets of the world around him.

In 1958, it was my privilege to introduce the legislation to create the National Aeronautics and Space Administration. I stated then: "I confidently believe that the developments of the Space Age will bring the beginning of the longest and greatest boom of abundance and prosperity in the history of man."

Time is bearing out that belief.

And so I take pleasure in submitting this report to Congress. It chronicles a great and exciting period of accomplishment and fore-shadows an even greater one. In commending this record, I also commend the men principally responsible for making it possible. James Webb and Dr. Hugh Dryden have guided and directed our nation's space program for nearly five years—and they have a grateful nation in their debt.

THE WHITE HOUSE October 22, 1965

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# Twelfth SEMIANNUAL REPORT TO CONGRESS

JULY 1 - DECEMBER 31, 1964

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION WASHINGTON, D. C. 20546



THE PRESIDENT
The White House

DEAR MR. PRESIDENT:

June 10, 1965.

We are pleased to submit to you the Twelfth Semiannual Report of the National Aeronautics and Space Administration, covering the period July 1-December 31, 1964, for transmittal to Congress in accordance with Section 206(a) of the National Aeronautics and Space Act of 1958. The report is divided into a "Period in Review" section, which summarizes the activities of the period, and an "Activities and Accomplishments" section, which describes Agency programs and progress.

During the period of this report NASA moved ahead on a broad front, extending its knowledge of the space environment, increasing its ability in space flight and aeronautics, strengthening its launch capability, and expanding its scientific investigations in space. It concluded the KIWI phase of the nuclear rocket program, entered the sixth year of flight research with the X-15 rocket plane, successfully tested the XV-5A vertical take-off and landing aircraft, conducted satisfactory tests of heat shield materials in the Project FIRE reentry experiments, and, for the first time, tested in space a small ion engine for electric propulsion.

More and more, the practical benefits of the space program began to be realized in the form of weather forecasting, storm warnings, navigation aids, and improved global communications. In addition, each United States success was so handled as to give further evidence that this Nation will use its growing space competence to demonstrate to all the potential of space and to develop space technology for the benefit of all mankind.

Respectfully yours,

James E. Webb Administrator

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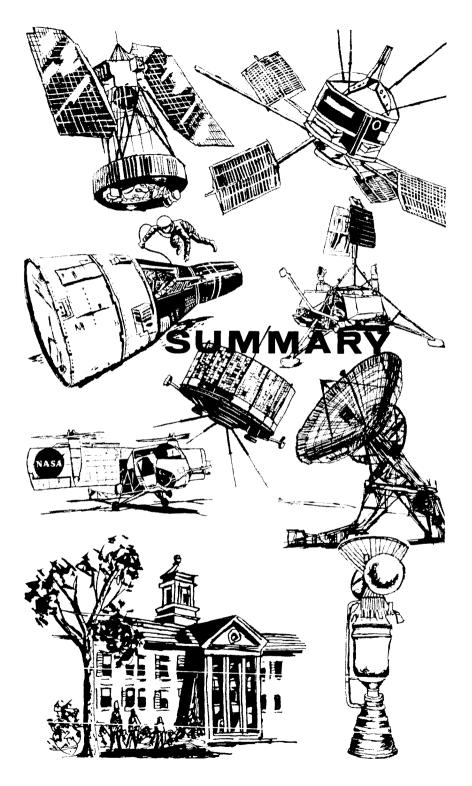
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#### THE PERIOD IN REVIEW

The time covered by this report was one of intense activity for the National Aeronautics and Space Administration: Preparations were made for the first manned flight in Project Gemini, a spacecraft sent back clear photos of the moon, another spacecraft was launched on a Mars mission, satellites were used extensively in meteorology and communications, and international cooperative endeavors increased. These and other activities are summarized in the following pages and detailed more fully in the subsequent chapters.

#### Manned Space Flight

In its manned space flight activities, NASA continued to achieve advances in both the Gemini and Apollo programs. Progress was made in the design, manufacture, and ground testing of space vehicle hardware and supporting equipment. Construction moved forward on the necessary industrial, test, and operational support facilities for both programs. Astronaut training continued, with special emphasis being given to specific mission training for the early Gemini manned flight crews. Studies were underway of advanced manned mission (post-Apollo) possibilities and the related program requirements.

By the end of the period, the Nation's government-industry manned space flight team reached peak strength, with a combined work force totaling approximately 300,000.

In the Gemini program, mission objectives were more specifically defined, and the spacecraft, launch vehicle, and rendezvous target vehicle were further developed and tested. The Gemini spacecraft for the second unmanned test flight was being readied for its mission, and the one for the first manned mission was delivered to the John F. Kennedy Space Center. Gemini Launch Vehicles and Gemini Target Vehicles were in various stages of manufacture and testing, preparatory to the 10 manned missions of the program.

In the space medicine efforts associated with the Gemini program, further work was done on the extravehicular life support system, on spacecraft instruments to monitor bodily functions, on the Gemini Environmental Control System components and subsystems, and on other related hardware. All medical ground support plans were in final form by the end of the period. The Gemini experiments program was expanded to 8 medical, 16 Department of Defense technological, 12 engineering, and 12 scientific experiments.

In the Apollo program, overall management efforts received increased emphasis, and substantial progress was made toward developing spacecraft, launch vehicles, a tracking and mission control network, and facilities. Design of the complete Apollo/Saturn V vehicle moved forward, with completion expected in 1965. Seven boilerplate (heavily structured copy of the flight model) spacecraft were delivered to NASA during the period. A complete ground test version of the spacecraft was delivered (to White Sands).

The first flight test spacecraft was manufactured and sent to system testing for subsystems integration. The first spacecraft Acceptance Checkout Equipment Station became operational in August, and compatibility tests between the spacecraft system and the ground support equipment were started. Thus, the ability for rigorous preflight testing of equipment was being developed in parallel with the ability to design and manufacture that equipment.

Designs were essentially frozen for the Command and Service elements of the Apollo spacecraft. The production design of the Lunar Excursion Module (LEM), the unit of the spacecraft which will land on the moon, was established. Command and service module subsystems delivered during the period included the first production model environmental control system, the first Apollo spacesuits, the first production units of the Guidance and Navigation system, and the first prototype communication system.

The seventh Saturn launch, September 18, 1964, was fully operational, testing the boilerplate spacecraft under launch conditions and in orbit. The Saturn I flights also provided verification of the RL-10 engines, proving technology of particular value to the J-2 hydrogen engine program.

Structural testing of various stages of Saturn IB and the much larger Saturn V was underway. A special test version of the propulsion system for the Saturn V second stage was successfully ground fired. The third stage of Saturn V was in manufacture.

Training activities continued for the 25 astronauts still available for flight crew assignments. These activities included design participation, general training, and specific mission training.

Activity in the scientist-astronaut program moved forward. Public announcement of the program on October 19, 1964, resulted in the receipt of over 1,500 applications and inquiries. Following initial NASA screening, about 400 applications were turned over to the National Academy of Sciences for scientific qualification screening. (Ten to 20 candidates are to be selected.)

Planning, design, and construction of major facilities continued. Facilities were either completed or well along at Kennedy Space Center, Manned Spacecraft Center, Marshall Space Flight Center, the

Michoud plant, at the Mississippi Test Facility, and at various other locations.

Beyond the Apollo Program, NASA continued analytical and planning efforts related to advanced manned missions. Work went forward in two areas: Apollo Extension Systems (AES) and new missions. Potential new mission areas under study would include extended lunar exploration missions leading to an outpost on the moon, earth orbital space stations of indefinite lifetime, and exploratory flights in deep space aimed at manned planetary exploration.

# Scientific Investigations In Space

In this area of activity, NASA accumulated substantial knowledge of the space surrounding the earth, the surface of the moon, and the nature of the interplanetary environment. Six small Explorer geophysical satellites were launched, and a 1,000-lb. observatory (OGO-I) was orbited carrying 20 integrated experiments for simultaneous observations in space. Explorer XXII experimented with laser tracking of satellites for the first time, and the launching of Explorers XXIV and XXV by a single vehicle marked another Agency first.

In July, Ranger VII photographed and transmitted thousands of high quality photographs of the moon, and in November, a Mariner spacecraft was successfully launched on a trajectory to flyby Mars in mid-July 1965. During the trip it was providing a wealth of scientific data. Considerable progress was also made in developing the first U.S. moon satellite (Lunar Orbiter) and Surveyor spacecraft to make soft lunar landings in preparation for future manned exploration.

NASA life scientists carried out preparatory work on experiments for later use in unmanned exploration of Mars and the search for life forms. A study contract was initiated for the preliminary design of an automated biological experiment system able to detect and describe life on Mars during a 2-year period.

The Agency also directed a broad-based, biological research program to investigate the effects of the space environment on living organisms and on maintaining men in space. Plans were made to support this program with a Biosatellite flight project of six recoverable orbiting biological satellites, the first scheduled for launching in 1966.

At university and other research facilities, scientists and engineers planned manned investigations of the moon and designed highly versatile instruments for this work. Flight hardware for experiments

scheduled to be carried on the first manned Gemini flight was delivered to the spacecraft contractor for installation. Meanwhile, scientists, responding to a notice that Apollo earth-orbital missions could accommodate experiments, proposed about 50 investigations for these missions.

# Light and Medium Launch Vehicles

Scout, Delta, Agena, and Atlas-Centaur launch vehicles orbit spacecraft in NASA's space science and applications programs. During the period, Scout vehicles successfully launched such spacecraft as the Ionosphere Explorer XX, the Beacon Explorer XXII, the Micrometeoroid Explorer XXIII, and (in a single launch) the Air Density and Injun Explorers XXIV and XXV. In August, a Delta boosted the Syncom III communications spacecraft into orbit and in December launched the Explorer XXVI energetic particles satellite. October, the Interplantetary Monitoring Platform Explorer XXI was launched by a Delta vehicle but did not achieve the planned orbit and consequently failed to accomplish all of its objectives. (All instruments were functioning well, however, and it was making planned measurements in the magnetosphere.)

One Atlas-Agena vehicle launched Ranger VII, and another launched the first Orbiting Geophysical Observatory in September. Other Atlas-Agena vehicles undertook to launch two Mariner spacecraft in November to photograph Mars. A first attempt failed with Mariner III. In the second attempt, Mariner IV was injected into the planned trajectory. The Nimbus I meteorological satellite was successfully orbited by a Thor-Agena launch vehicle combination in August.

Atlas-Centaur, this country's first launch vehicle using liquid hydrogen, was being developed for lunar and planetary explorations. Development of this direct ascent vehicle, initially intended to carry Surveyor spacecraft to soft land on the moon, is expected to be completed in 1965.

### Satellite Applications

Launched in August, Syncom III became the first geostationary satellite in the world as it "hovered" over a point on the Equator. It was used to relay TV coverage of the Tokyo Olympic games to the United States. Later, it was used in conjunction with the Agency's Relay I to transmit TV pictures to Europe.

Telstar II—built and owned by A.T. & T. and orbited May 7, 1963 continued to operate satisfactorily, linking Europe with North America in communications experiments. The second Relay, launched in January 1964, was used for over 1,600 experiments and more than 100 technical and public demonstrations. NASA also experimented with its three other orbiting communications satellites—Syncom II and the passive communications satellites Echo I and II.

The Nimbus I second generation meteorological satellite supplied improved daylight cloud cover pictures, and its new infrared radiometer provided high quality cloud pictures at night. By the end of December, the 8 spacecraft in the TIROS series had supplied more than 400,000 cloud cover pictures—over 80 percent of them meteorologically useful. They also observed 25 hurricanes and 51 typhoons. TIROS I (Eye), the next in this series, will be built like a cartwheel and will be able to provide daily global cloud cover data. (Orbited in January 1965 as TIROS IX, this satellite proved to be highly successful.)

Agency studies indicated that satellites could be an aid to air and sea navigation, traffic control, and rescue activities. Accordingly, the Departments of Treasury, Defense, Interior, and Commerce, and the Federal Aviation Agency, joined NASA in forming a committee which began to analyze and evaluate such a satellite system.

In addition, NASA renamed its Advanced Technological Satellites Program the Applications Technology Satellites (ATS) Program to describe its objectives more accurately. The ATS project, managed by Goddard Space Flight Center, will conduct research, development, and flight testing of technology which may be useful in a number of applications.

NASA also entered into an agreement with the Communications Satellite Corp. to provide launching and related support services for satellites in the Corporation's "early capability" program. NASA will be reimbursed for all costs actually incurred in each launching.

#### Advanced Research and Technology

In this area, NASA conducted wide-ranging investigations in space power technology, space vehicles, spacecraft electronics and control, aeronautics, biotechnology and human research, chemical propulsion systems, and basic research.

For the space power technology program, solar cells were flight tested on balloons, solar cells more resistant to radiation were used by Nimbus I, and cells able to operate at higher temperatures were investigated. Work was started on an advanced lightweight, highenergy generator suited to space applications, and one using solar energy was successfully tested. Aluminum electroforming processes for fabricating very large solar collectors were shown to be practical, and progress was made in research on materials capable of storing thermal energy.

Research on batteries included production and testing of a more powerful experimental cell, test operation of a high temperature power pack, and refinement of a hybrid battery/fuel cell. High-performance fuel cell electrodes were tested, and a low temperature hydrogenoxygen fuel cell was operated for over 500 hours. Advances were also made in development and testing of techniques and devices to improve performance and increase reliability of space electrical power systems.

Space vehicles research continued with the completion of the M-2 lifting body flight program and the ordering of two vehicles. parachute was developed capable of recovering a 10,000-pound spacecraft, thermal radiation from plastic heat shield materials was studied, and several materials capable of shielding against high-energy protons were investigated. Data was collected on meteoroids by a recoverable probe and by the Explorer XXIII satellite (launched November 6), which used thin pressurized cans to record meteoroid penetrations. (Discussed in chap. 2, p. 51 and chap. 4, 90). Research was conducted on propellant behavior in space-vehicle tanks during weightlessness, techniques for measuring extremely low pressures, electroluminescent panels to automatically control the rate of absorption of solar energy by spacecraft surfaces, and reflective white paints for passive control of the temperatures of liquid hyrdogen storage A new and potentially highly efficient method of absorbing the impact energy of spacecraft landings, nonmetallic air locks for space rendezvous, and expandable structures for lunar shelters were investigated. Finally, the first Project FIRE experiment provided considerable data on heating of a blunt spacecraft reentering the atmosphere at about 28,000 miles per hour.

In spacecraft electronics and control, lasers were tested for satellite tracking, and narrow optical beams were studied for use in the application of lasers to deep space communication. A technique was investigated for reducing the number of bits of information that must be transmited to earth from a spacecraft. Called Previous Element Coding, this method may make it possible to double the amount of information transmitted over a communications channel. Computer memories capable of storing 100,000 bits of information in a cubic inch may result from work on thin-film, laminated memory materials. A prototype of a hybrid computer which can make 1,000 computations a second was completed. And fluid computer systems were found to be reliable in extreme environmental conditions.

Aeronautics research covered a wide range of activities, including tests of a slotted-flap wing section for subsonic jet transports and of configurations and different wing shapes for supersonic aircraft. For the supersonic transport, studies were completed of a clipped-delta-wing-body combination and of a model incorporating flaps between and in addition to leading-edge and trailing-edge flaps. A large jet air-

craft acquired to support space science and aeronautical research programs will be used for airborne observation of a solar eclipse in May 1965. Also, continued tests of an air bag passenger restraint system indicated the possibility of reducing crash impact on passengers substantially. V/STOL aircraft research included studies of the effects of blade stall on rotor operation and efforts to develop theory for predicting this phenomenon; wind tunnel and flight tests of propeller-driven tilt-wing aircraft; stability and control studies of a scale model tilt-wing aircraft; analyses of lifting jets on a VTOL model; and flight investigations of the influence of directional stability on V/STOL handling qualities.

Biotechnology and human research programs varied from studies of the effects of stress on physiological responses to investigation of tether lines linking astronauts to their spacecraft. A prototype life-support system for operation up to 1 year was being constructed, equipment to protect man against vibration, acceleration, and impact was being developed, a locomotion system responsive to voice controls was studied, and data was collected on the biological effects of the proton component in radiation likely to be encountered in space flights.

The solid propulsion research program achieved successful tests of 156-inch diameter motors and preparations for the manufacture of the 260-inch diameter motors. New liquid rocket engine design concepts were shown to be feasible, and the RL-10 upper stage engine was test operated with the efficient fluorine-hydrogen propellant combination.

Representative of the work in basic research were laboratory studies verifying plasma theory, application of the mathematical method of averages to space flight mechanics, the development of a new series of polymers with stability at high temperatures, research on production and use of the rare element technetium as an alloying addition, and investigations of susceptibility of titanium alloys to stress corrosion cracking. Finally, in electrophysics research, pulsed coherent acoustics wave energy was produced by a new technique which may be used for probing the structure of matter. This work is described in greater detail in chapter 4.

# Nuclear Propulsion and Power Generation

In its nuclear propulsion and power generation activities, NASA's efforts included significant reactor experiments in the KIWI project. The success of these experiments represented a major step toward the economical development of nuclear rockets. The KIWI project was concluded, and efforts were being concentrated on development of higher power reactor technology.

Concurrently, two significant NERVA reactor experiments were

conducted. Both were also successful. In the second, conducted on October 15, all test objectives were met, with the reactor operating stably and reliably. Related efforts were devoted to developing the nonnuclear components necessary for ground engine system testing, the nozzle, and the hydrogen feed system. The turbopump was designed and was being fabricated.

The reactor development effort under the NERVA program was being complemented by work on the PHOEBUS advanced graphite technology project (which uses graphite to obtain higher power levels). The current activities were aimed at designing, fabricating, developing, and testing high-powered PHOEBUS 2 reactors. Tests of PHOEBUS 1 (KIWI-sized) reactors were also being planned to provide additional design data and technological information. Some clustering experiments of these KIWI-sized reactors were performed. In addition, work was initiated to develop the technology of major non-reactor components for a PHOEBUS-reactor type engine.

The safe use and handling of nuclear rocket reactors and associated propellants were receiving considerable attention. Studies and experiments were being conducted to assure safety under all conceivable circumstances.

In the SNAP-8 program, all major power conversion system components were being tested and the first system was nearly constructed. By the end of the period, the SNAP-8 experimental reactor had been operated for over 7,800 hours. While the boiler performed satisfactorily after run-in, it did not develop superheat reliably at start-up; corrective steps were being taken.

NASA's nuclear electric power research and technology efforts were directed toward finding ways of converting nuclear thermal energy into electric energy for both auxiliary power and propulsion engines. Testing began on the first large potassium vapor turbine, and thermionics conversion research continued. Also, further steps were aimed at building a Brayton (gas turbine power system) turbomachinery technology base.

In another area of effort, NASA was investigating the possibility of generating electric power in space directly from a moving, electrically conducting working fluid. In addition, a magnetohydrodynamic power plant concept was being investigated. Work in the electric propulsion program was focused on evaluating competing thrustor systems for satellite control and on investigation of three types of thrustors (electrostatic, electrothermal, and plasma). A Space Electric Rocket Test (SERT I) conducted in July verified research results, showing that an electric thrustor could work in space.

Three types of 3-kilowatt thrustors were being evaluated, fabricated, or tested, while the concepts of four other types were being researched. (These are discussed in detail in ch. 5.)

# Tracking and Data Acquisition

Tracking and data acquisition networks continued to support NASA and DOD flight programs, covering 22 launches (including three DOD satellites) during the period. Updating of the networks to support future flights progressed as planned.

The operational capability of the Satellite Network, including the Space Tracking and Data Acquisition Network (STADAN) and 12 optical tracking stations, was further extended by completion of the third medium-gain antenna installation at Santiago, Chile. The STADAN supported 16 of the launches made during the period and 31 in all. The optical stations provided orbital data for 21 satellites and tracked 15 to obtain data for precise measurement of atmospheric and magnetic properties affecting satellite orbits.

The Manned Space Flight Network is now modified to support Gemini launches. New equipment was added and integrated into the systems used for the Mercury program. Additional radar display and telemetry systems were installed at the primary stations. Both high-frequency and ultra-high frequency links were established for communications reliability between the two Gemini astronauts and the ground station, permitting simultaneous communication with both men. The network successfully supported the Saturn (SA-7) launch of September 18.

New facilities were being added and new and advanced electronic systems were being developed in support of the Apollo program. Plans were being made to augment the Gemini network with new stations, antennas, command, telemetry, data processing, and communication systems.

The Deep Space Network, used primarily to support lunar and planetary programs, was also being augmented. At Canberra, Australia, construction of the S-band 85-ft. antenna was completed and operational checkout started. The 210-ft. parabolic antenna station (Goldstone, Calif.) and the 85-ft. station (Madrid, Spain) were also under construction. Also, an interim system for the Woomera, Australia, and Johannesburg, South Africa, stations was completed. This network tracked the Ranger VII spacecraft during its successful lunar mission; it was also tracking and communicating with the Mariner IV spacecraft as it moved on its planned trajectory toward Mars.

#### International Programs

NASA and the Italian Space Research Commission cooperated in launching the first Italian (and the fourth international) satellite into orbit from NASA's Wallops Island Station. On July 8, NASA

and the European Space Research Organization (ESRO) signed a Memorandum of Understanding under which ESRO will build two satellites for NASA to launch in 1967.

The first foreign experiment to fly on a NASA satellite was one to study the ionosphere prepared in the United Kingdom and launched on Explorer XX in August. One French, one Netherlands, and two United Kingdom experiments were accepted for flight on the OGO-E satellite to be launched in 1967.

Sounding rocket experiments were conducted with Argentina, Germany, India, Japan, New Zealand, Pakistan, Sweden, and the United Kingdom, and agreements were made with the Netherlands and Norway/Denmark for additional sounding rocket projects.

Agreement was reached with the Soviet Academy of Sciences for the exchange of conventional and satellite meteorological data over a special Washington-Moscow communications link established in November.

Scientists at 61 foreign stations in 27 countries cooperated with NASA in obtaining data from the Explorer XXII satellite launched in this period. Many foreign stations received cloud cover photographs from the Automatic Picture Transmission (APT) subsystem of NASA's Nimbus satellite.

NASA expanded the facilities at its ground stations in the Malagasy Republic and Nigeria and was making arrangements with a number of governments to station Project Gemini contingency recovery units in their territories.

NASA's Deputy Administrator and the Assistant Administrator for International Affairs were technical advisors to the United States Representative to the meetings of the United Nations Committee on the Peaceful Uses of Outer Space.

In education, personnel exchanges, and technical training, 65 post-doctoral research associates from 21 countries worked at NASA Centers, and 64 graduate students from 16 countries studied space science at 17 American universities. In connection with agreed co-operative projects, 74 technicians from Italy and ESRO received training at NASA Centers. And over 1,600 foreign nationals from 72 countries visited NASA facilities for scientific and technical discussions or general orientations.

#### Grants and Research Contracts Activities

NASA's Sustaining University Program provided support for 1,957 predoctoral students at 131 institutions, with 1,071 of these doctoral candidates starting their work during this period. One hundred forty-two institutions were selected to take part in the pro-

gram in fiscal year 1965; 11 of these were participating for the first time.

Facilities grants totaling \$5,889,000 were made to six universities: Southern California, Cornell, Purdue, New York, Arizona, and Illinois, and to the Polytechnic Institute of Brooklyn. Two facilities were completed—the Space Sciences Laboratory, University of Chicago and the Propulsion Sciences Laboratory, Princeton University, and construction was started at three institutions—University of California at Los Angeles, Massachusetts Institute of Technology, and Polytechnic Institute of Brooklyn.

Six grants were made to three universities, and 25 multidiscplinary research programs were continued as part of the research element of the Sustaining University Program.

Appointments under the NASA-National Academy of Sciences Resident Research Associates Program were held by about 60 scientists at Goddard Space Flight Center, Ames Research Center, and Marshall Space Flight Center. Lewis Research Center and Manned Spacecraft Center will participate in this program in 1965.

#### Informational and Educational Programs

The Selective Dissemination of Information (SDI) system became fully operational as 500 Agency scientists and engineers began to receive computer-based announcements of technical reports and journal literature matched to their work and interests. In the area of education, NASA helped over 275 colleges and universities plan space science courses and arranged summer workshops for nearly 14,000 teachers.

In addition, the Agency's spacemobile lecture-demonstration teams supplied information on space science and exploration to over 1.7 million schoolchildren, teachers in training, and civic groups. Spacemobile lecturers on television were seen by over 10 million viewers. NASA also engaged in adult education projects to help increase public understanding of the national effort in space.

Finally, the Agency continued to make available technical and nontechnical publications and educational films, radio and TV presentations, exhibits, and historical materials.

# Personnel Management, Procurement, and Support Functions

In personnel activities, the Agency acted to further improve employee-management cooperation; moved ahead with its existing training activities, developing a new management seminar and an executive management orientation; further implemented the Affirmative Action Program for Federal Employment (required under

Executive Order 10925); and took additional steps to assure appointment and career development of women in scientific, technical, and administrative positions. The staff increased from 32,499 to 33,108 during the period. Also, through awards and honors, NASA continued to recognize groups and individuals for their contributions to the space program.

The Agency's Inventions and Contributions Board processed 53 petitions for waiver of patent rights, recommending that 48 be granted and 5 be denied. The Board also evaluated 625 new scientific and technical contributions and recommended that the Administrator grant four awards. In addition, it made 20 monetary awards (none exceeding \$5,000) to NASA employees for patentable inventions.

Under its patent program, NASA initiated a new foreign patent program and revised its patent waiver regulations to implement the President's Statement on Government Patent Policy of October 1963.

Organizational improvements included establishment of the Electronics Research Center at Cambridge, Mass.; realinement of manned space flight operations functions to meet requirements for concurrent Gemini and Apollo launch schedules; appointment of a NASA European representative; and appointment of an Assistant Administrator to assume fulltime responsibility for Technology Utilization.

During the period, the Agency's cost reduction effort showed measurable savings in excess of \$100 million. Thirty-one contractors voluntarily agreed to participate in the cost reduction program.

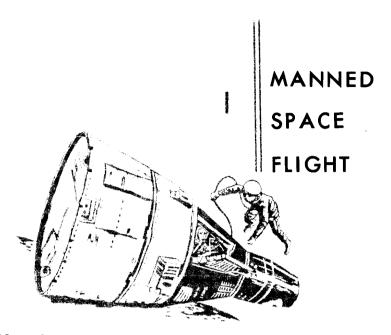
Procurement policies and procedures were updated, and NASA established an informal procedure for participating with DOD in negotiating advance agreements with major contractors for reimbursement of independent research and development costs. The Agency also established a new policy concerning its procurement relationships with foreign countries, with respect to the balance of payments.

Incentive contracts were increased from 54 to 68, the dollar values rising from \$541 million to \$725 million; 11 other contracts were in the process of negotiation.

NASA procurements for the period totaled \$2,928 million, with 82 percent of the net dollar value being placed directly with business firms. Small business firms received 5 percent of NASA's direct awards to business; they also received \$218 million in subcontract awards.

The Agency's Technology Utilization program stressed identification of new technology, and refined and expanded its efforts to make available to new users technical information gained from Federally-funded research.

# ACTIVITIES AND ACCOMPLISHMENTS RANGER VII



Manned space flight efforts continued to move toward the first manned Gemini mission, in early 1965, toward further development and test goals in the Apollo program, and toward completing studies that must precede the undertaking of longer-range space exploration programs.

Two significant launches occurred during the period, the seventh Saturn I and the third Apollo/Little Joe II tests. These brought to 20 the total number of consecutive successful major launches conducted by NASA in the manned space flight program beginning April 28, 1961. (The total includes three unmanned and six manned Mercury flights, seven Saturn I flights, one in Gemini, and three suborbital Apollo tests.)

The management capability required to achieve manned space flight objectives also received continuing emphasis. The organizational structure was strengthened and refined, and the NASA/industry team approached a peak strength of about 300,000 persons. Important strides were made in the area of program management, and certain management tools were adopted to measure performance relative to established goals.

Major facilities were completed or were nearing completion. Construction proceeded at the three manned space flight Centers. Facilities were completed for the manufacture, assembly, and test of the Saturn V second and third stages and for the engines of all three stages.

The 25 astronauts in flight crew status received both general and

specific-mission training. They also took part in hardware design and development reviews. In addition, NASA completed the initial screening of applications for the scientist-astronaut training program. The National Academy of Sciences was reviewing for NASA the applicants' scientific qualifications.

Studies and evaluations further defined the Agency's plans to exploit the Apollo program investment through the extended use of Apollo hardware for further applications, with planning efforts being divided into two general areas, representing two successive time phases in development. These are identified as the Apollo Extension Systems, allowing maximum exploitation of the Apollo hardware investment, and new missions.

The specific details of manned space flight accomplishments are discussed in the sections which follow.

#### The Gemini Program

During the period, the Gemini program closely approached the second unmanned flight (occurring on Jan. 19, 1965) and progressed in all aspects preparatory to the first two-man mission. Concurrently, mission objectives were more specifically defined; overall management effort was given increased emphasis; and the development and test efforts associated with the spacecraft, launch vehicle, and rendezvous target vehicle proceeded according to plan.

#### Gemini Objectives

Gemini mission objectives are planned to accomplish the second phase of the Nation's manned space flight program, and to acquire the knowledge and experience that are prerequisite to the Apollo lunar landing mission.

One of the primary objectives concerns the human factor. Gemini long duration flights will increase flight-time from several orbits to missions possibly running 2 weeks (more than required by the Apollo mission). Controlled physiological studies of exposure to space flight will be conducted and crew interactions will be studied.

Another very significant objective of this program is to develop the ability to launch within a narrow time span, to rendezvous with another craft in space, to dock firmly with it (see fig. 1-1), and ultimately to maneuver the combined vehicle. A progression of Gemini flights is scheduled to develop this ability as well as to investigate and evaluate several electronic and optical methods for programing rendezvous maneuvers.

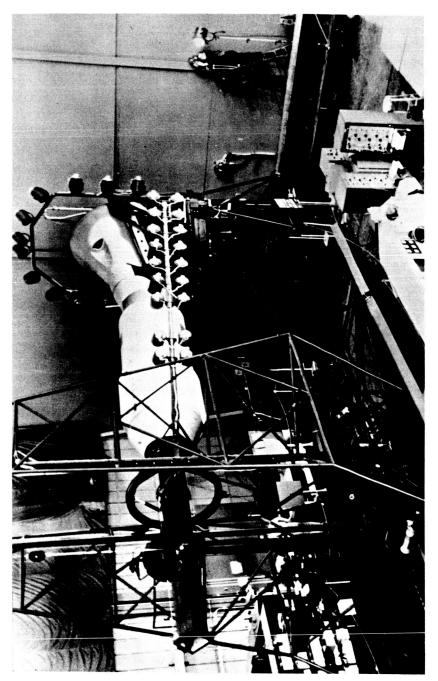


Figure 1–1. Gemini docking trainer.

Still another Gemini objective is to develop flight-path control methods for bringing the spacecraft from space into selected landing areas. The Gemini crew will be able to exercise a measure of control over their reentry flight path by maneuvering their craft. This technique will be required in the Apollo program on return missions from the moon.

Gemini astronauts are also expected to develop the capability to exit from the spacecraft into space. This extravehicular capability is of great importance for future missions which will require maintenance, repair, and assembly of equipment in space.

#### Flight Program

Gemini mission planning during the period brought about several modifications to better utilize the Gemini spacecraft. One of the more significant changes, which did not increase the total number of flight missions, was the addition of a flight mission of up to 4 days duration to precede the 7-day mission. This manned mission of up to 4 days is a required step to gain knowledge of the effects of long exposure to the space flight environment.

The first Gemini mission, GT-1 (reported in the Eleventh Semiannual Report), was an unmanned orbital flight to test the Gemini Launch Vehicle performance and the ability of the spacecraft and launch vehicle to withstand the launch environment. This test was successful.

The GT-2 mission had been scheduled to precede the first Gemini manned flight planned for the last quarter of 1964. This schedule held until a combination of natural circumstances delayed the mating of the GT-2 vehicle until it was necessary to reschedule GT-3 into 1965.

The series began with a lightning strike on Pad 19 in August, causing damage to the electrical systems of the launch vehicle. Extensive rework was required, including replacement of all semiconductors in the vehicle. Later in the period, hurricanes Cleo and Dora made it necessary to remove the launch vehicle from the pad and then to erect it again. As a result, the GT-2 launch date was set for December 8.

An on-board malfunction on December 8 caused engine shutdown, and a minor redesign of the engine actuator was necessary. This delay caused the rescheduling of GT-2 to January 1965 and the shift of the first manned Gemini launch to March 1965.

#### Management

The Gemini program includes the spacecraft and launch vehicle; a target vehicle and booster; the equipment necessary to support the astronauts and develop their capabilities to perform their missions; the facilities required for development; the facilities, equipment and per-

sonnel needed to conduct flight operations; and program management.

To accommodate the changing aspects of the program, such as the transition from the developmental to the operational phase, and to provide adequate control and visibility of the program, changes resulting in strengthened management evolved during this period. The Gemini Executives Group, established earlier in the year, continued to provide a means of close communication between NASA and contractor top management. This group met periodically to discuss particular problems of the program and to develop a better understanding of what must be accomplished. In the area of program control, changes and additions were made to strengthen the Manned Spacecraft Center Gemini Program Control Office to meet the changing demands of the program. Additionally, a Test Operations Office was established in the MSC Gemini Program Office to manage the extensive test activities.

A significant management accomplishment was the conversion of the Gemini Spacecraft contractor's contract from a cost-plus-fixed-fee to an incentive type. This addition to the list of major Gemini contractors brings the total value of incentive contracts in Gemini to over a half billion dollars, and all the major contractors are under incentive contracts. The program has already benefited in such areas as schedule stabilization, more effective cost control, better middle management performance, plantwide incentive awareness, and reduced overtime.

#### Development, Production, and Test

Gemini hardware production to support the flight operations phase of the program during this period approached a peak level. Most of the development and qualification testing of the spacecraft, target vehicle, and launch vehicle was completed. Some tests, mostly related to missions to be flown later in the program, were being carried over into 1965.

With design and development of the Gemini systems essentially completed, reliability and quality assurance efforts were being concentrated in the fabrication, assembly, checkout, and flight operations phases. During the period, failure mode and effect analyses of the Gemini systems were completed. All instances of a single-point failure mode (a single failure that would necessitate a mission abort) were identified and suitable precautions were taken by means of redesign, redundancy, or backup systems.

Spacecraft.—The Gemini spacecraft consists of an adapter and a reentry module, as shown in fig. 1-2. The adapter is made up of the equipment and retrograde sections; the reentry module consists of the cabin, the reentry control, and the radar and recovery sections.

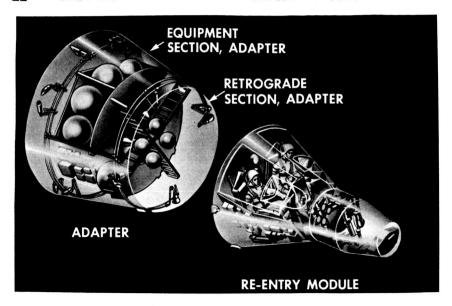


Figure 1-2. Gemini spacecraft adapter and reentry module.

Production of the spacecraft is carried out in three phases: manufacturing, final assembly, and systems testing. At the end of the period, manufacturing was under way for all spacecraft not yet completed. As for the earlier ones: Numbers 1, 1A, and 2 had been delivered before July 1964. Spacecraft number 3 was delivered to the Kennedy Space Center during the report period. Spacecraft 3 was intended for mission GT-3, the first manned Gemini flight. (See fig. 1-3.) Number 3A, a flight-configured spacecraft, was being used to conduct thermal balance evaluations in the vacuum chamber at the contractor's plant. It is not to be flown but will be used for postflight investigations. Spacecraft number 4 was undergoing spacecraft systems tests and spacecraft 5, 6, and 7 were in final assembly.

Gemini Target Vehicle.—The Gemini Target Vehicle is an Agena D modified to provide a very flexible command capability, responding either to real time or to stored program commands from both the spacecraft and ground control. It is provided with a spacecraft docking adapter and has been modified to permit several restarts of the engine in space. Small thrust engines have been added as secondary propulsion systems to provide propellant orientiation and small changes in velocity. (See fig. 1-4.)

The first Gemini Target Vehicle underwent integrated systems test and was installed in the test stand at Santa Cruz in preparation for static firing. (The first Agena vehicle was to be delivered to NASA in 1965 for use as a development test vehicle and as a backup flight vehicle.) The Agena flight vehicle to be used in the first Gemini rendezvous mission will be vehicle No. 2. This vehicle was in manufacturing during the period and was scheduled for delivery in 1965.

Gemini Launch Vehicle.—The final item of major flight hardware is the Gemini Launch Vehicle (GLV), a modified Air Force Titan II. Development and qualification of the Gemini Launch Vehicle is complete. The first vehicle was successfully launched in April 1964,

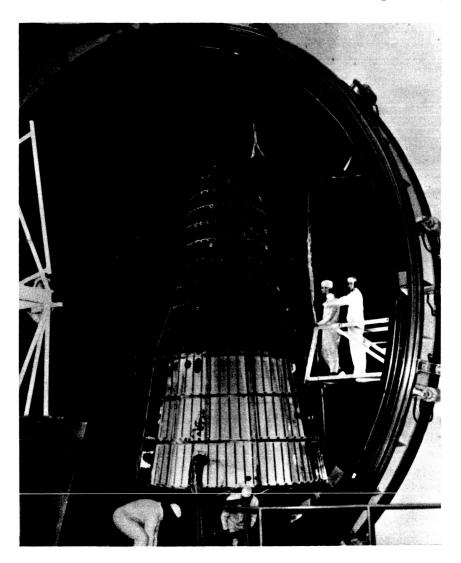
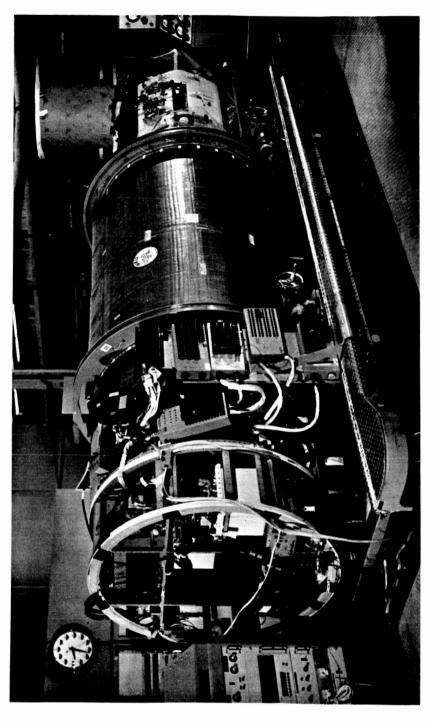


Figure 1-3. Spacecraft 3A thermal test preparation.





providing launch vehicle flight qualification. (The second GLV was successfully flown in the GT-2 flight on Jan. 19, 1965.) Gemini Launch Vehicle 3 was completed during the report period, and Gemini Launch Vehicle 4 was in final systems testing in December 1964. Gemini Launch Vehicles 5 and 6 were in final assembly and the propellant tanks for Launch Vehicle 7 were being assembled during this period.

#### Space Medicine

The success of any manned mission depends upon the physical well-being and proficiency of the astronauts. As the duration of the flight becomes extended, the importance of the human element increases. The requirement becomes more exacting for protective measures and equipment to insure the adequate function of body systems and the efficient performance of the individual. To meet this requirement, Gemini space medicine activities are carried on in three basic areas: life support, medical operations, and medical experiments.

During the period, these activities were directed toward the flight qualification of equipment and systems to be used in the Gemini GT-3 and GT-4 flights and toward the further development and improvement of equipment and systems to be employed in later flights. These activities included further work on the extravehicular life support system; spacecraft bioinstrumentation; the Gemini Environmental Control System components and subsystems; improved food packaging; improvement of survival and personal hygiene equipment; definition and refinement of medical experiments; food, water, and waste systems, and other hardware such are tethers and life support umbilical lines.

By the end of the period, flight qualification was accomplished for the food, water and waste systems, survival equipment, personal hygiene equipment, and bioinstrumentation. Development of the intravehicular flight suit was continued. The GT-3 suit was qualified, and development of the extravehicular spacesuits was initiated. The design and development of the life support systems for the Gemini extravehicular mission was begun. Also, ground based experimental medical studies supporting manned space flight requirements continued. These included developmental work in biomedical, in-flight experiments, and control medical studies, the latter in support of the long duration flights. Two series of experimental studies were completed—the vibration force tolerance tests, and the spacesuit and components compatibility test.

In the area of medical support of Gemini manned flight, mission objectives were defined, medical aspects of the flight plan were estab-

lished, medical mission rules were formulated, and the flight data analysis plan was completed. All medical ground support plans, including those for recovery and monitor forces and for the necessary equipment and facilities, were in final form by the end of the period. This area of medical operations reflects a high degree of cooperation and joint effort with the Department of Defense.

### Gemini Experiments

In Gemini the Nation has its first manned platform upon which to carry out significant space experimentation. By the end of the period, 48 experiments were planned for the Gemini program.

The Gemini experiments program was expanded to obtain more experimental data on man's ability to perform useful work in space. Eight medical experiments will be conducted to gather more information on man's reactions to the space environment. Sixteen Department of Defense technological experiments will provide insight into the applications of manned space flight such as extravehicular activity, navigation, photography, and astronaut visibility. Twelve engineering experiments require placing equipment on the space vehicle to obtain supporting technology for Apollo and for long range NASA space programs. The 12 scientific experiments will provide a balanced program in astronomy, biology, geology, meteorology, and physics.

## The Apollo Program

Throughout the period, the Apollo program was characterized by the continued planning and buildup of effort necessary for the successful and timely accomplishment of the lunar landing mission. The overall management efforts were further emphasized, hardware development and testing moved forward according to a balanced and carefully phased schedule, and operations planning advanced. Substantial progress was made toward developing the spacecraft, the launch vehicles, the tracking and mission control network, and the checkout and launch operations facilities required by the program.

## Specific Mission Objectives

Specific Apollo mission objectives are to be accomplished in two major phases. The first phase consists of the flights of the Apollo/Saturn IB space vehicle: Unmanned flight qualification, short duration manned flights, long-duration missions, and, later, flights to carry out rendezvous and docking exercises with the Apollo spacecraft. The second phase will be the missions of the Apollo/Saturn V space vehicle: Unmanned flights, followed by manned flights consisting of a lunar mission simulation and then lunar missions. (Fig. 1-5.)

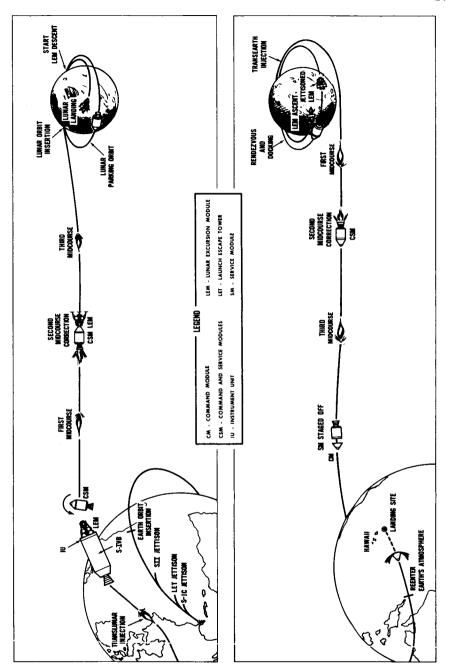


Figure 1-5. Apollo lunar landing mission (top, outbound; bottom, return).

The unmanned qualification of the Apollo/Saturn IB space vehicle is scheduled for 1966, followed by manned earth-orbital flights in 1967. Unmanned flights of the Apollo/Saturn V are also scheduled for 1967. The manned flights of Apollo/Saturn V are scheduled for 1968, leading to the manned lunar landing and return before the end of the decade. During the report period, the last 2 of the 15 flights now approved as a part of this program were rescheduled for calendar year 1970. Previously, all 15 flights were scheduled for completion by the end of calendar year 1969. The schedules for the early flights in this program remained unchanged. This change extended the Apollo program by about 6 months; the average schedule delay was about 3 months.

The Apollo lunar landing mission requires the capability for maneuvering in space, whether it be near earth or a quarter of a million miles out. Carrying out this misssion demands high levels of technology and reliability. Once developed, these new capabilities can be employed for scientific investigations, for space exploration, and for new technological applications. They will also serve as a foundation for further steps in the development of our space flight capability.

### Apollo Management

The Apollo Program Office at NASA Heaquarters is responsibe for overall direction of the Apollo design, development, and manufacturing effort in which all three manned space flight centers participate. The Marshall Space Flight Center (MSFC) is responsible for development of the Saturn I, Saturn IB, and Saturn V launch vehicles and engines, and for associated ground-support equipment and flightoperations support. At the Mississippi Test Facility, under the control of MSFC, the first and second stages of the Saturn V vehicle will be acceptance tested. The Manned Spacecraft Center (MSC) is responsible for development of the Apollo spacecraft and ground-support equipment, space-flight crew training, and support of manned space-flight missions. John F. Kennedy Space Center (JFKSC) is responsible for Apollo launch operations, launch facilities, and common ground-support equipment. It also provides tracking for the initial launch phase of NASA missions in conjunction with the Air Force Eastern Test Range.

Support for the Apollo program is received from other NASA centers—in particular the Goddard Space Flight Center; the Ames, Langley and Lewis Research Centers; and the Jet Propulsion Laboratory. Tracking and data acquisition stations also provide support under the management of the Office of Tracking and Data Acquisition.

At White Sands Missile Range, N. Mex., development tests of Apollo spececraft-propulsion systems and launch-escape systems are con-

ducted. Testing of the lunar excursion module experimental training vehicle is carried on at Edwards Air Force Base, Calif. At the Arnold Engineering Development Center, Tenn., environmental testing of components and systems takes place, and at El Centro, Calif., Apollo spacecraft parachute drop tests are made.

## Design Status

In Apollo, the program definition is essentially complete, as is the basic design for the Apollo/Saturn IB vehicle to be employed in the earth-orbital missions. Preliminary design has also been completed for the Saturn V launch vehicle and the lunar excursion module of the spacecraft. The design of the Apollo/Saturn V space vehicle is expected to be completed in 1965. The design is sufficiently conservative to provide for contingencies arising from information provided by early development flights regarding the space environment. This conservatism will manifest itself in the margins of the design itself and in the retention of flexibility to make changes in such subsystems as the lunar excursion module landing gear and the service module outer shell.

## Development and Testing

As the space vehicle design and subsystem development phases approached completion and test hardware was delivered, major emphasis in the Apollo program was shifting to ground development test. Apollo development testing begins at the component level, builds into subsystems, systems (stages and modules), and finally to the entire space vehicle ready for flight. These tests, in turn, lead to the final verification of the space vehicle design by tests in actual flight.

Spacecraft.—During the period, plans called for the delivery of six boilerplate spacecraft. A total of seven were actually delivered. A complete ground test spacecraft service module, containing all of the flight systems, was delivered for use in propulsion tests at White Sands. A second spacecraft was rescheduled for delivery in early 1965. This rescheduling was done to allow the contractor to deliver a more critically needed boilerplate spacecraft for use in the checkout of subsystems for the first flight test spacecraft. Manufacture of the first flight test spacecraft was completed and sent to system testing for the integration of subsystems. (It is scheduled for flight in 1966 as a part of the first Apollo/Saturn IB space vehicle.)

The first spacecraft Acceptance Checkout Equipment Station (ACE-S/C) became operational in August and compatibility tests between the spacecraft system and the ground-support equipment were started. A second ACE-S/C station at the same contractor's installation became operational in December.

Apollo command and service module spacecraft development utilizes two configurations. These are the basic Block I configuration for the earth-orbital missions, and the more advanced Block II configuration incorporating design changes for the lunar mission. In September, a mockup review of the Block II command and service modules was held at the contractor's plant. (Fig. 1–6.) Following this review, the designs of these lunar mission modules were essentially frozen.



Figure 1-6. Block II command module mockup.

A major accomplishment during the period was the NASA/contractor review of a hard-metal mockup of the Lunar Excursion Module (LEM) shown in figure 1-7. Following this review, the LEM production vehicle configuration was established.

Major command and service module subsystems were delivered. These included the first production model environmental control system, the first prototype communication system, the first production units of the Guidance and Navigation System, and the first Apollo space suits.

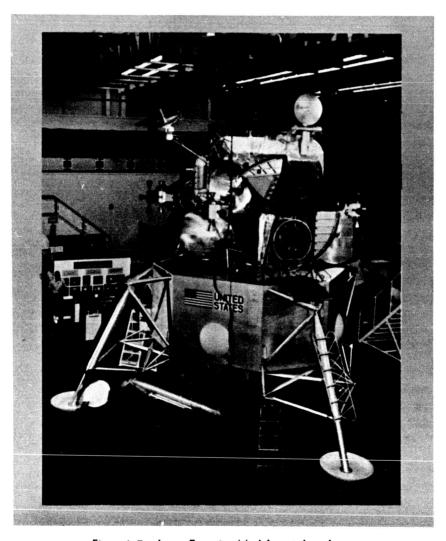


Figure 1-7. Lunar Excursion Module metal mockup.

The development testing of the spacecraft instrumentation system was completed. Also, development tests were completed on the command module and service module reaction control systems. The fuel cell design verification tests were completed, and three fuel cell modules connected in parallel were successfully tested. (Fig. 1–8.)

The service propulsion engine component development tests were completed, and the Propulsion Systems Development Facility at White Sands was activated. This is the facility where a complete system with flight-type tankage and spacecraft components will be

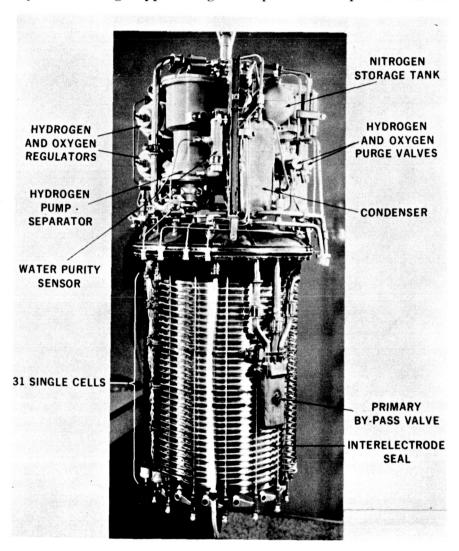


Figure 1-8. Apollo major fuel cell components.

tested. The lunar excursion module development test program experienced a sharp buildup during the period, particularly in the component and subsystem areas. Major hardware articles used to support vehicle and subsystem development include mockups, engineering test models, propulsion test rigs, and Lunar Excursion Module test articles. Very intensive test programs continued at each of the spacecraft engine subcontractor's plant facilities. This effort will continue in 1965, with engine qualification starting later in the year. Also, propulsion demonstration firings at White Sands started and will continue to support the flight test program as required.

The canard system for effective operation of the Launch Escape System (LES) was proven out on a Little Joe II firing. (Fig. 1-9.) The requirement for this canard was determined from extensive wind tunnel test programs conducted at various facilities throughout the country. Two Little Joe II flight tests (one during the preceding period) have verified the LES during the transonic and maximum dynamic pressure phases of flight; they also confirmed the adequacy of parachute deployment. A second type of test of the LES and the development spacecraft was carried out during the period on the seventh flight of the Saturn I vehicle to further confirm the structural compatibility of the two elements under flight conditions. (In essence all of our spacecraft flight tests to date have been successful.)

Launch Vehicles.—Development of the necessary launch vehicle capability for the Apollo program has been based upon a series of three successive vehicles of incremental size and power, the Saturn I, Saturn IB, and Saturn V launch vehicles. All Saturn I development and qualification testing was completed in May 1964, requiring a total of only six launches instead of 10 originally planned. The seventh flight, SA-7, was a fully operational launch vehicle mission in which a boilerplate Apollo spacecraft was tested under launch environment and in orbit. (Fig. 1-10.)

The Saturn I flight program also provided verification of the RL-10 engine program, a significant factor in substantiating the NASA decision to use liquid hydrogen fuel for upper stages of large launch vehicles. The RL-10 program enabled NASA to prove this technology at minimum cost for extrapolation into the other engine programs, particularly the larger J-2 hydrogen engine. Qualification tests of the RL-10 engine were completed in September 1964.

Structural testing of the Saturn IB first stage (S-IB) in support of the first two Saturn IB flights neared completion. Structural testing for later Saturn IB vehicles, which have a lighter configuration, was under way. Also, the manufacture of the dynamic test S-IB first stage was completed, with delivery to MSFC scheduled for early 1965. The structural proof tests of the Saturn IB second stage (S-

IVB), in support of the first two flight stages, were completed. Structural testing in support of later vehicles was continuing.

On December 23, 1964, the S-IVB battleship stage was successfully fired for a full duration run of 415 seconds. This completed the basic battleship test program for the Saturn IB/S-IVB. In four previous runs (Nov. 24-Dec. 15) a total of 221 seconds of short duration test firings were obtained. At the end of the period, the battleship stage was being readied for flight engine type battleship testing.

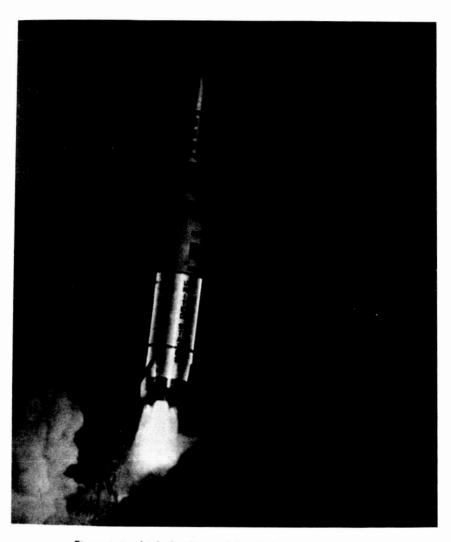


Figure 1-9. Little Joe II test of Apollo launch escape system.

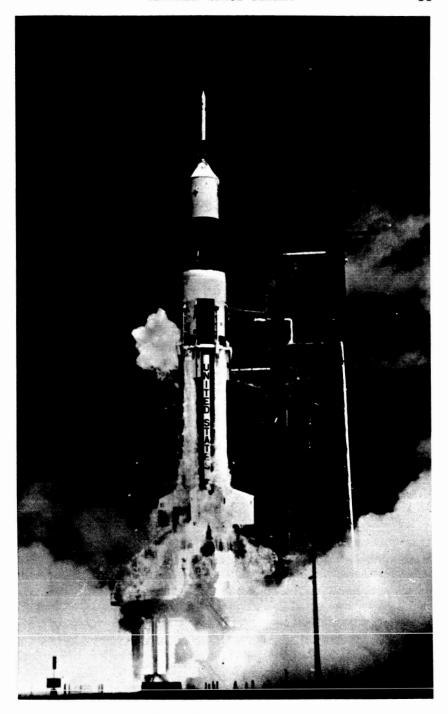


Figure 1–10. Saturn I (SA-7) launch, September 18, 1964.

The S-IVB dynamic test stage was en route to MSFC in December 1964. The stage was transported by freighter via the Panama Canal to New Orleans, then by barge to the Marshall Center. All Saturn V ground test stages were in various phases of manufacture at the end of the period. (Fig. 1-11.) Fabrication of the first stage (S-IC) systems, structural, and dynamic test stages was started. The assembly of the systems stage at the Marshall Space Flight Center (MSFC) was underway. In addition, fabrication of the first flight stage was begun; this stage will be used on the first Saturn V flight vehicle.

A major milestone was achieved with the successful ground firing of the Saturn V second stage (S-II) battleship propulsion system. In this test, the J-2 engine served for the first time as an integral component of the stage. Another milestone was reached with the successful manufacture and assembly of the common bulkhead required for the Saturn V second stage. The first bulkhead for this stage was successfully assembled, and assembly of the structural, systems, and dynamic test stages was started. The assembly of the structural, systems, and dynamic test stages for the second stage was also underway, as was fabrication of the first flight stage.

The third stage (S-IVB) used on the Saturn V vehicle is similar to the second stage of the Saturn IB. Therefore, the ground test stages fabricated for the development ground test program are to be used for both the Saturn IB and Saturn V vehicles. Fabrication of the S-IVB stage for the first Saturn V flight vehicle was in progress at the end of the period.

Qualification of the up-rated H-1 engine (for the Saturn IB first stage) was delayed in order to incorporate several significant improvements in addition to the uprating to 200,000 pounds thrust. This uprating will permit 2,000 additional pounds of payload to be lifted by the Saturn IB launch vehicle, increasing the total to 35,000 pounds in earth orbit. By deferring H-1 engine qualification, NASA will be able to qualify the engine with the additional changes in a single formal qualification program rather than two separate programs. (Fig. 1-12 shows the engines to be used for space flight.)

The preflight rating test of the J-2 engine was successfully completed in November 1964. (This engine is used in the Saturn IB second stage and Saturn V second and third stages.) The final flight rating test of the engine to verify stage compatibility was scheduled for completion during 1965. Flight rating tests of the F-1 engine for the Saturn V first stage was completed according to schedule. (The F-1 engine was the first engine project to be undertaken by NASA following its creation in 1958, and F-1 engine readiness is a major milestone in the Apollo program.)

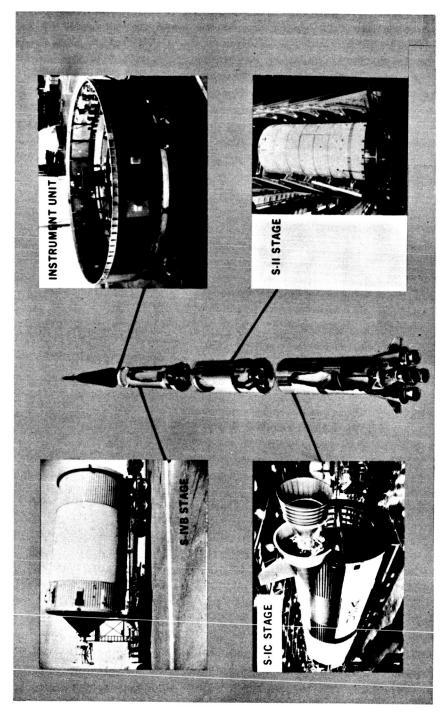


Figure 1–11. Saturn V launch vehicle.

Instrument Unit.—The Instrument Unit contains the guidance and electronics for the Saturn launch vehicles. It is composed of six major subsystems which must guide and control the launch vehicle during launch and flight. Two versions of the Instrument Unit for the Saturn I have been developed. The first version was pressurized to provide the environment necessary for the components that were not hermetically sealed. Successful sealing of the components resulted in the much lighter weight unpressurized second version Instrument Unit.

The successful unpressurized Instrument Unit (IU) design for Saturn I was basically retained for Saturn IB and V. Many of the IU components from Saturn I were undergoing refinement for use on these latter vehicles, a good example being the ST-124 inertial platform in the guidance system. The ST-124 platform provides inertial reference for launch vehicle attitude, for steering error computations, and for position and velocity information. Prototype models of the ST-124 inertial platform were carried as passengers on earlier Saturn I flights (SA-3 and SA-4), and an early production model was flown on flight SA-5 as a unit of an operating guidance system. On the flight SA-7 the ST-124 inertial platform provided full active guidance and control.

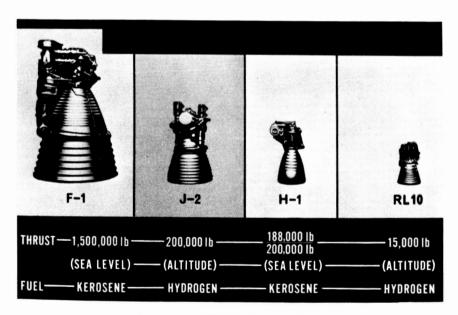


Figure 1-12. Engines for space flight.

### Astronaut Activities

NASA has selected a total of 30 astronauts in three groups, with a composite background of about 80,000 hours of flight experience. This experience includes operating complex flight systems, dealing with emergency situations, evaluating equipment design and fabrication, and developing flight procedures and techniques. With the retirement of Colonel Glenn and the fatal crash of Captain Ted Freeman on October 31, 1964, 28 astronauts remain in the program. Astronauts Slayton, Shepard, and Carpenter are in key managerial positions but are currently not in space flight status, leaving 25 astronauts available for flight crew assignments.

### Astronaut Design Participation

To insure man-machine compatibility and harmony, the astronauts participate in hardware design and development. Recent astronaut design participation included the Lunar Excursion Module (LEM) Design Review and crew mobility studies during the M-5 Mockup Review of the LEM in October. An important collateral benefit to the astronaut's training is gained from design participation.

## General Training

The astronaut training program consists of general training applicable to all manned space flight and specific mission training for Gemini and Apollo missions. General training includes science and technology summary courses, operations familiarizations, environmental familiarization, contingency training, physical training, and aircraft space flight readiness training.

During the preceding report period, each member of the third group of astronauts received about 240 hours of academic instruction in 12 science and technology summary courses. Several of these courses were also attended by members of the earlier groups of astronauts as new or refresher courses. Geology is scheduled on a continuing basis for all astronauts to prepare for exploration of the lunar surface. Several geology field trips throughout the country were conducted. Also, environmental and contingency training activities of the third group of astronauts were completed. Environmental training included high G in a centrifuge, low or zero G in aircraft parabolic trajectory flight, and spacesuit familiarization. Contingency training included parachute training and desert, tropic, and water survival courses. High performance aircraft and helicopter flying provides

at lowest cost the overall stress environment most closely simulating space flight and is the means of developing and maintaining required piloting skills.

## Specific Mission Training

Specific mission training was concentrated in the Gemini program. All astronauts underwent Gemini part-task training and launch vehicle abort training. The third group of astronauts received Geminicentrifuge training in November and docking training in November and December.

Extensive mission-oriented training was given both the crew and backup crew selected for particular missions. This training is conducted in devices which as nearly as possible simulate mission conditions. Virgil (Gus) Grissom and John Young, as the primary crew for GT-3, and Walter Schirra and Thomas Stafford, as backup crew, underwent such training for several months. Similar training was being taken by the primary crew of the GT-4 flight, James A. McDivitt and Edward H. White, and by the backup crew, Frank Borman and James A. Lovell.

This training for 6 months before the mission is devoted to familiarization with spacecraft, with the mission profile, with experiments which are to be conducted, and with all emergency procedures. Wateregress training is conducted in a boilerplate spacecraft. Mission simulation is carried out with the two Gemini Mission Simulators now operational, one at Kennedy Space Center and one at MSC. A moving base docking simulator and a part-task trainer (adapted from the former Mercury-procedures trainer) are also operational at MSC.

All MSC simulators were to be moved in early 1965 from their interim housing to the central location at MSC, allowing efficient maintenance and operation of the equipment. Visual display systems which provide a realistic out-the-window view to the astronaut in a simulator were in their final stages of development and were expected to be attached to the two Gemini Mission Simulators by mid-1965.

The training hardware for Apollo specific mission training was in the development stages, with completion expected during fiscal year 1966. The Lunar Landing Research Vehicle, which will evolve into a unique free-flight lunar landing trainer in fiscal year 1966, flew for the first time on October 30, 1964, at the Flight Research Center, Edwards, Calif., with Project Pilot Joe Walker at the controls. (Fig. 1–13.)

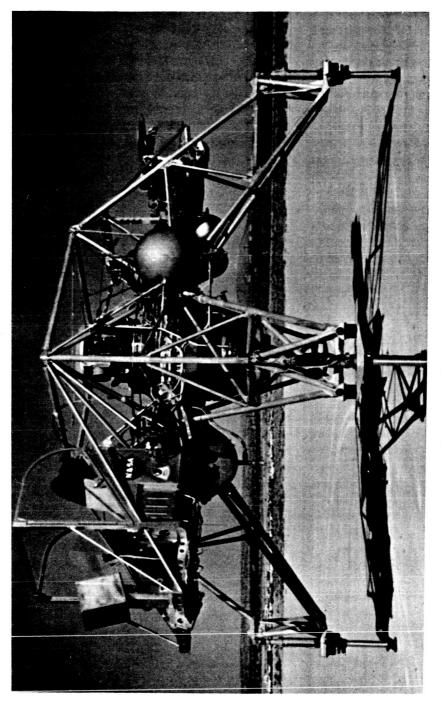


Figure 1–13. Free flight trainer.

## Scientist-Astronaut Program

To insure maximum benefit from the scientific exploration opportunities of later Apollo missions and in advanced manned space flights NASA is proceeding with a selection program for scientist-astronauts. This program was developed throughout the past year in cooperation with the National Academy of Sciences. The recruiting process began with a public announcement of the program on October 19, 1964, giving background, criteria, and application instructions. Applicants must have been born on or after August 1, 1930, be citizens of the United States, be not taller than 6 feet, and have a bachelor's degree and a doctorate in the natural sciences, medicine, or engineering, or possess the equivalent in experience. Also, they must have indicated a creative ability.

Over 1,500 applications and queries were received by NASA. Initial screening by the Manned Spacecraft Center was to be completed early in 1965, after which the National Academy of Sciences will conduct the additional screening for scientific qualification of the remaining eligible candidates. A final selection of 10 to 20 scientist-astronaut candidates was to be announced later in 1965.

# Supporting Facilities

Considerable management attention was given to the planning, design, contracting, and construction of the major facilities required for the manned space flight program. Major facilities were completed or were nearing completion. Schedules were held, and the Agency was taking the necessary action to make certain that they would continue to be held. In carrying out this facilities program, NASA continued to receive effective support from the Army Corps of Engineers, the Navy Bureau of Yards and Docks, and from other government agencies.

## John F. Kennedy Space Center

At Kennedy Space Center, construction of facilities for the Apollo mission moved ahead rapidly. By the end of December, the steel framework of the Vehicle Assembly Building (VAB) stood more than 400 feet high. The VAB will be 524 feet high upon completion, providing space for assembly and checkout of the 360-foot Apollo/Saturn V space vehicle. One mobile launcher for Launch Complex 39 was fabricated and erected, and construction of two others was nearing completion. Assembly of one of the world's largest ground vehicles, the crawler transporter for moving the Apollo/Saturn V space vehicle from the VAB to the launch pad in vertical posi-

tion was almost completed. Also under construction were the pads and crawler-ways.

Acquisition of approximately 88,000 acres comprising the Kennedy Space Center Merritt Island Launch Area adjacent to Cape Kennedy, Fla., was completed. Two main areas of construction, the Merritt Island Industrial Area and the Launch Complex 39, progressed rapidly.

In the Industrial Area, the following were completed: The operations and checkout building, the supply shipping and receiving building, the supply and GSE service building, the weight and balance building, hypergolic test building No. 1, the cryogenic test building, the environmental control systems building, the fluid test support building, the radar boresight range, the parachute building, the ordnance storage building, the Industrial Area utilities and roads, the central supply facility, the medical facility, the cable maintenance and storage facility, the plant maintenance facility, and the auditorium. In the same area, contracts were awarded for the following major facilities: Central instrumentation facility, hypergolic test building No. 2, supply and GSE building addition, base operations building, operations and checkout building addition, and the flight crew training building.

Also completed were two causeways, one across the Banana River between Cape Kennedy and MILA, and the other across the Indian River connecting MILA with the mainland. Modification to Launch Complex 34, for launching Saturn IB, was progressing rapidly and was scheduled for completion in 1965. A Visitors Information Center was under design for construction on Merritt Island, west of the Industrial Area. This facility will contain a display area, a presentation area, a tour gathering area, and a lounge.

## Manned Spacecraft Center

At the Manned Spacecraft Center, Houston, Tex., the addition to the environmental testing laboratory was under construction, the addition to the thermochemical test facility was completed, and the flight acceleration facility was being built. Another facility which progressed rapidly during the report period was the Mission Control Center—Houston (previously known as the Integrated Mission Control Center). The Houston Mission Control Center will control the second manned Gemini flight and subsequent Gemini missions. The Mission Control Center at Cape Kennedy (formerly Mercury Control Center) will serve as backup. The technical services facility, the lunar mission and space exploration facility, the electronic sys-

tem compatibility facility, a branch cafeteria building and supporting utilities, and other additions to the Manned Spacecraft Center were in either the late design or the early construction phase.

# Marshall Space Flight Center

At the Marshall Space Flight Center, the buildup of facilities achieved several milestones. Within the Laboratory and Support Areas the following facilities were completed: Engineering and administration building, engineering building, addition to computation division building, components and subassembly acceptance building, Saturn V barge dock and loading facility-and extension of primary utility systems, components test facility, F-1 turbo pump stand, hydraulic test facility, low temperature test facility, and the instrument laboratory.

This period also saw the completion of major test facilities such as the F-1 engine test stand, the Saturn V dynamic test stand, and the load test annex. The static test stand for the Saturn V first stage was substantially completed. This facility was scheduled to be operational in the spring of 1965. The Saturn V ground support equipment test facility was placed in partial operation to meet scheduled requirements. Final completion was to take place during the first part of 1965.

#### Michoud Plant

At the Michoud Plant in New Orleans where the Saturn S-IB and Saturn S-IC stages are manufactured, construction was completed for the engineering building. The high bay vertical assembly and hydrostatic test buildings were also completed. The stage checkout facility was nearing completion, and construction of the vehicle component supply building and the road system which will accommodate stage transportation to Port Michoud was initiated.

## Mississippi Test Facility

At the Mississippi Test Facility NASA will static test the first and second stages of the Saturn V vehicle. During the report period, acquisition of approximately 126,000 acres of buffer zone was substantially completed, and construction of the test and support facilities was progressing. Within the Saturn V Complex, progress was made on construction of the first test stand for the S-II (second) stage and related technical and support systems. The foundation of the second S-II stand was completed and construction of the superstructure was underway. Construction of the S-IC Complex facilities also pro-

gressed. The foundation of the dual position S-IC test stand was complete and test stand substructure was nearing completion. Construction of the first position superstructure was initiated.

In the Industrial and Administrative Areas, the following facilities were completed: The emergency service building, site maintenance building, central heating plant, telephone building, the first increment of the warehouse, water wells and distribution systems, cryogenic docks, and railroad classification yard.

#### Various Locations

At Edwards Air Force Base, Calif., where production acceptance testing of the F-1 engine is performed, three new engine test stands with supporting facilities were completed and became operational. At Seal Beach, Calif., construction of the S-II stage assembly and test facilities was completed. These included a vertical assembly and hydrostatic test facility, a structural static test facility, a pneumatic test and packaging facility, and the loading dock.

Construction of facilities for the S-IVB stage test and development program at Sacramento, Calif., was essentially complete. Two static test stands, a control center, a propellant gas storage and transfer system and the attitude control motor test facility became operational. A two-position vertical checkout facility for post firing checkout was under construction. This facility, in conjunction with the two test stands, will permit maintenance of planned delivery rates of the S-IVB stages.

In summary, the Apollo program continued to show steady progress during the period. The successful tests and other accomplishments provided a sound basis for NASA's increased confidence that the actual lunar mission can be carried out by the end of the decade.

## Advanced Manned Missions

The Apollo and Gemini programs can be exploited in a wide range of earth orbits, lunar orbits, and lunar surface missions. Exploitation of these capabilities constitutes an important forward step in the logical development of the Nation's manned space flight program. Therefore, NASA continued to devote effort to the investigation, analysis, conceptual design, and evaluation of possible future missions. During the report period, planning efforts were divided into two general areas, representing two successive time phases in development. These were, first, the Apollo Extension Systems (AES) which represent maximum exploitation of the Apollo hardware investment; and, second, new missions. These new missions include extensive ex-

ploration of the moon, an earth-orbital space station, and manned planetary exploration.

## Apollo Extension Systems

During the period, NASA conducted several intensive studies of possible advanced manned missions. These studies were carried out in conjunction with a thorough evaluation of the state of technology employed in presently approved programs and in the NASA Advanced Research and Technology programs. This assessment led to the recommendation that plans for the immediate future should thoroughly exploit the investment in the Apollo/Saturn system by applying its wide range of capabilities to a number of other potential missions.

Major Earth Orbital Application Areas.—In the AES, three major application areas can be derived from earth orbital operations: (1) flights to conduct scientific research in space requiring man's presence; (2) earth-oriented applications; and (3) development of advanced technology to support both manned and unmanned space operations.

In the field of earth-oriented applications of manned space operations, NASA was conducting a variety of studies and investigations, some of these jointly with other agencies of the Government, such as the Departments of Commerce, Agriculture, Interior, and Defense. One purpose of these investigations was to seek a means of helping the responsible agencies to forecast weather and communicate globally at high data rates. Another purpose was to determine the practicality of the control of air traffic on a global scale, of a worldwide air-sea rescue service, and of a data-gathering system on a global scale. And for the more distant future, NASA was studying such possibilities as an up-to-date inventory of the world's resources and better forecasts of food production.

Experiments were also being evaluated to enhance overall support of space operations. Biomedical, behavioral, and other medical studies would be conducted as well as the development of advanced subsystems and technology for spacecraft. Great forward strides will be made in each of these areas in the coming years, especially as the various equipment and procedures are investigated, evaluated, and developed by actual flight tests in space. The extended Apollo is being considered for this purpose, also.

Lunar Exploration.—Another logical extension of the Apollo program studied during the report period was the mapping, surveying, and exploration of the moon from lunar orbit. By means of a single flight of 28 days in lunar polar orbit, the complete surface of the moon

could be photographed in great detail. Such a mission would be invaluable for scientific study of the moon; it would also provide the data needed to select the areas of greatest interest for follow-on surface exploration.

The follow-on surface exploration could be accomplished by landing an unmanned lunar excursion module (LEM) carrying the exploration equipment and life support provisions for mission duration up to 2 weeks. The astronauts would follow up by landing nearby in a second LEM and then transferring operations over to the first LEM, which would serve as a crew shelter on the lunar surface. After completion of the mission, they would abandon the first LEM and return to the second LEM for the trip back to earth.

#### New Missions

Beyond these extended Apollo missions, and depending upon the information developed from them, future missions were also being considered: (1) Extended lunar exploration missions which can culminate in a continuously supported outpost on the moon; (2) earth orbital space stations of indefinite life time; and (3) exploratory flights in deep space, aimed at manned planetary exploration. The Agency's study activities were aimed at evaluating the most feasible mission modes, defining the resources required, and establishing the mission requirements.

Lunar Missions.—The extension of lunar exploration beyond the AES program will require greater mobility on the lunar surface. An attractive approach is the use of a separate LEM descent stage—or LEM truck—which could deliver a payload of 8,000 lbs. on the lunar surface. This payload could be a mobile laboratory. Further increases in cargo would depend on the development of a direct-flight logistics spacecraft.

Earth Orbital Missions.—The foundations of a long-range national space program will be based largely on what is learned from the earth-orbital missions. While using Apollo hardware in AES will provide valuable earth-orbital experimental capability, many important experiments will be larger, more crew members will be required, and longer durations will be necessary. For example, the long-duration effects of weightlessness, confinement, and other space environmental factors upon man's physiological and psychological condition constitute an area of extreme importance, one that can be investigated thoroughly only by means of an advanced earth-orbital system. These considerations have led to the orbiting laboratory or space station concept.

Planetary Missions.—In the planetary area, mission analyses and conceptual design studies were continuing in order to identify the critical advanced technology requirements and the possible alternative means of mission accomplishment. Studies also cover the possibilities of early manned Mars or Venus flybys, based largely on in-development hardware and the possible implications for AES and space station module development.

Overall, the advanced manned missions planning efforts underway during the period continued to lay the groundwork for space efforts beyond the Apollo lunar landing mission. The intensive studies being conducted were pointing the way toward through exploitation of the Apollo/Saturn systems, as well as toward broader application of technology now being developed.



The following achievements are evidence of the noteworthy progress made in this area of activity during the reporting period:

- Transmission by Ranger VII of over 4,000 high-quality pictures of the Moon's surface.
- Successful launching of Mariner IV to fly by Mars in mid-July 1965.
- Fist NASA launching of two satellites (Explorers XXIV and XXV) by a single launch vehicle.
- Orbiting of Explorer XXV, first satellite completely designed and built by a university (State University of Iowa).
- Launching of the first Orbiting Geophysical Observatory.
- Orbiting of the Italian San Marco spacecraft, first satellite built and launched by a team of foreign nationals.

# Physics and Astronomy Programs

Seven artificial earth satellities were obited in NASA's physics and astronomy programs during the last half of 1964. Six were of the small Explorer class; the seventh was a large advanced type of satellite—an orbiting observatory.

# Explorer Satellites

Explorer XX, a fixed-frequency topside sounder, was launched on August 25 into a near polar orbit at an altitude of about 600 miles (fig. 2-1). Its primary purpose is to study the upper terrestrial iono-

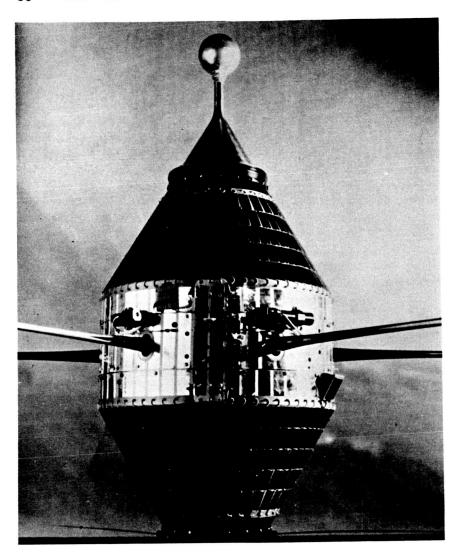


Figure 2-1. Explorer XX.

sphere from above—a region which cannot be reached by direct sounding from the ground. In this the satellite resembled the Canadian spacecraft Alouette orbited September 29, 1962, but the experimental methods differ and supplement each other.

Explorer XX uses six fixed radio frequencies between 1.5 and 7.2 megacycles beamed downward in rapid succession to the ionosphere (Alouette used a swept frequency technique covering a wide band of frequencies.) Radiation scattered back to the satellite gives in-

formation on the height of the upper ionosphere layers and on electron densities in those layers. Explorer XX is able to seek out finer details of the ionosphere which escaped Alouette. The spacecraft continues studies of the ionized portions of the earth's atmosphere started by a number of earlier satellites. These investigations of the interaction of solar radiation with the atmosphere relate directly to scientific studies of radio communications. Explorer XX will also search for radio frequencies generated in space.

On October 3, Explorer XXI was orbited to investigate energetic particle radiations and magnetic fields in space beyond the limits of the earth's magnetic field (magnetosphere). Its instruments and scientific objectives are similar to those of Explorer XVIII (launched on November 26, 1963), and it continues research undertaken by Explorers XII, XIV, and XV on phenomena in space which vary continually like our weather on earth.

Explorer XXI fell short of its planned apogee (166,000 miles), reaching a maximum distance of 59,253 miles from the earth. This shortcoming severely limited its measurements in the space beyond the earth's magnetosphere and its ability to map the transition region at the boundary of the magnetosphere. However, all instruments were functioning well and will make the planned measurements of trapped particles, cosmic rays, and magnetic fields in the magnetosphere. This Explorer is of the Interplanetary Monitoring Platform (IMP) class designed to furnish information on the radiation hazards of manned space flight as a function of solar activity.

Explorer XXII, an ionosphere beacon, was launched on October 10 into a near polar, near circular orbit. Its primary objective—to determine the total electron count in the ionosphere between the satellite and the earth—will be achieved by means of radio transmission from a beacon in the satellite to the ground using frequencies of 20, 40, 41, and 360 megacycles. Requiring only simple ground equipment, the experiment allows participation by any number of scientists in countries along the satellite's orbit. More than 150 scientists in over 30 nations are participating in this global survey of the ionosphere.

Explorer XXII also carries 360 one-inch quartz corner reflectors for the first experiment in laser tracking of satellites. When fully successful, laser tracking will permit greater accuracy in observing orbital positions of satellites by using short wavelengths of light instead of the wavelengths of radio beams now used in satellite observations. Reflection of the red ruby laser beam transmitted from the ground to Explorer XXII was detected in 10 separate satellite passes during the spacecraft's first month in orbit.

Explorer XXIII, launched November 6, although not part of the physics and astronomy program, carried instruments to study micro-

meteoroid flux, distribution, and penetration similar to those carried on Explorers VI, VIII, VIII, XIII, XVI, and on deep space probes. While Explorer XXIII is concerned primarily with the damage which micrometeoroids may cause to spacecraft, it will also supply data on micrometeoroids and their distribution in space.

Explorers XXIV and XXV were launched November 21 by a Scout vehicle in NASA's first multiple launch by a single vehicle. The spacecraft will provide more detailed data on radiation-air density relationships in the upper atmosphere. Explorer XXIV, a 12-foot balloon inflated after being orbited, is of the same design as Explorers IX and XIX. By means of orbital tracking, the effects of atmospheric drag on the satellite were being studied. These studies of drag make it possible to determine atmospheric density and temperature in regions of the upper atmosphere where direct measurements by instruments are difficult due to the low density or hard vacuum. Explorer XXIV will also supply data on the interactions of solar phenomena with the upper atmosphere. Its measurements will be correlated with simultaneous measurements at other points in space being made by Explorer XIX.

Explorer XXV, an Injun-type satellite designed by the State University of Iowa to study the Van Allen region and energetic particles, is the first of this type flown by NASA and the first of the university Explorers. The 90-pound Explorer carries 16 sensors to measure corpuscular radiation from space which streams down into the earth's atmosphere; it also carries a magnetometer to measure magnetic fields.

On December 21, Explorer XXVI was orbited to study natural and artificial radiation belts surrounding the earth. The 101-pound satellite, carrying five experiments, was the latest in NASA's energetic particles series which has included Explorers XII, XIV, and XV.

Major objective of Explorer XXVI is to help scientists understand how high energy particles are injected, trapped, and eventually lost in the radiation belts. The satellite's oval orbit (16,200 miles apogee, 190 miles perigee, inclination 20 degrees to the Equator) carries it deep into the Van Allen radiation belt.

During this period Explorer XVIII, launched November 26, 1963, supplied data which led scientists to conclude that the satellite passed through a previously undetected wake in the solar wind created by the moon.

## Orbiting Geophysical Observatory

OGO-I (the first Orbiting Geophysical Observatory) was successfully launched on September 5, and placed in a highly elliptical orbit

ranging from 175 to 92,721 miles. (Fig. 2-3.) Although the observatory was spinning in orbit (and therefore considered a failure), the mission contributed significantly to an understanding of earth-sun relationships. The satellite weighed more than 1,000 pounds—5 to 10 times those of the Explorer class. Its 20 experiments were designed to take simultaneous readings and produce integrated studies of solar cosmic rays, gamma rays from the sun, trapped radiation (protons and electrons) in the earth's magnetosphere, galactic cosmic rays, the earth's magnetic field and the magnetosphere, the solar plasma or low energy solar wind, very low frequency (VLF) noise and propagation in the upper atmosphere, and related investigations. Review of the experiments indicated that 10 will provide data of sufficient quality to meet original objectives while 8 others will meet half or more of their objectives; only 2 were severely compromised.

OGO-I, in addition to being the largest satellite yet launched by the United States, demonstrated that a large number of integrated experiments can operate simultaneously to survey the space environment.

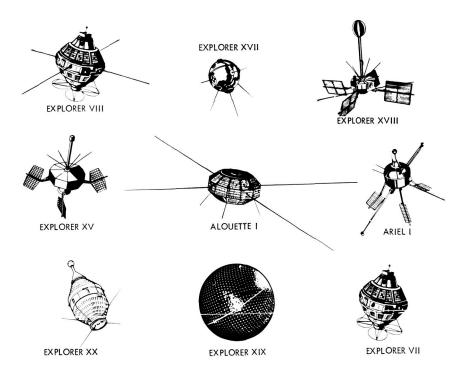


Figure 2-2. The Explorer satellite series.

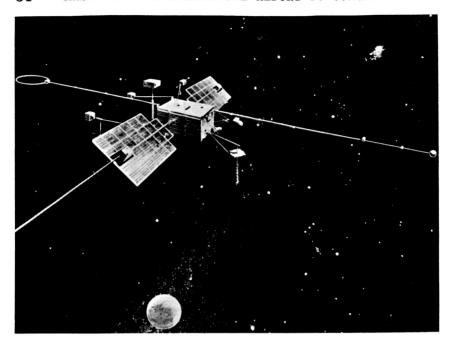


Figure 2-3. Sketch of the first Orbiting Geophysical Observatory.

#### San Marco Satellite

On December 15, the Italian Commission for Space Research launched a 254-pound San Marco satellite from Wallops Island. Designed and built by Italians, the satellite conducts continuous measurements of air density using an original method involving two concentric spheres. Its launch by an American-trained Italian crew marked the first time in NASA's international cooperative program that a NASA satellite launch operation was conducted by a foreign team. The 26-inch spherical spacecraft is in an orbit which ranges from 128 to 510 miles and is inclined 38° to the Equator; its orbital period is about 95 minutes.

A primary objective of this mission was to qualify the spacecraft for the later launch of a similar satellite into an equatorial orbit from a platform in the Indian Ocean near the Equator.

# Sounding Rockets

During the second half of 1964, 60 sounding rockets were successfully launched. One rocket made the first ultraviolet spectral observations of the earth's sunlit atmosphere from above, using an instrument similar to one to be used aboard the Polar Orbiting Geophysical Observatory (POGO) in a 1965 launch.

NASA also participated in a worldwide synoptic study of atmospheric motions or winds at altitudes between 50 and 125 miles. Eight countries made 30 launchings from 11 sites in both hemispheres; both day and night launchings took place at various locations extending from the equatorial to the polar regions.

# Lunar and Planetary Programs

Advances in NASA's lunar and planetary programs during the last 6 months of 1964 were highlighted by the transmission of thousands of high quality photographs of the moon's surface by Ranger VII's TV cameras in July. Also outstanding was the successful launching in November of a Mariner spacecraft in an attempt to fly by Mars in mid-July of 1965. In addition, substantial progress was made in developing the Pioneer, Lunar Orbiter, and Surveyor spacecraft.

## Ranger

After extensive redesign and retesting, Ranger VII was successfully launched from the Atlantic Missile Range on July 28 at 12:50 e.s.t. (fig. 2-4). Trajectory correction was made 17 hours after launch to bring about the lunar impact at 10.7° south latitude and 20.7° west longitude, only 7 miles from the aiming point.

The flight was normal in all aspects. At about 17 minutes before impact the full-scan TV cameras began transmitting pictures back to earth, followed by the transmission of pictures from the partial-scan cameras 5 minutes later. Video signals were recorded on magnetic tape and 35 mm. film at the Goldstone (Calif.) Receiving Station. The six cameras obtained a total of 4,316 pictures. In the final pictures, surface features as small as 15 inches were photographed—photographs 2,000 times clearer than those supplied by the most powerful telescope on earth.

#### Mariner

Mariner III—the first of two spacecraft planned to fly by Mars—was launched by an Atlas-Agena on November 5, but could not complete its mission because its shroud failed to separate completely. The problem was traced to a structural failure of the shroud and a new one was designed for the launch of the next in the series (Mariner IV).

Mariner IV (fig. 2-5) was launched successfully on November 28, and was providing a wealth of scientific data on the interplanetary environment en route to its flyby of Mars in mid-July. Before it passes within about 5,000 miles of the planet, it will have traveled over 350 million miles. As part of its mission, the spacecraft will relay TV

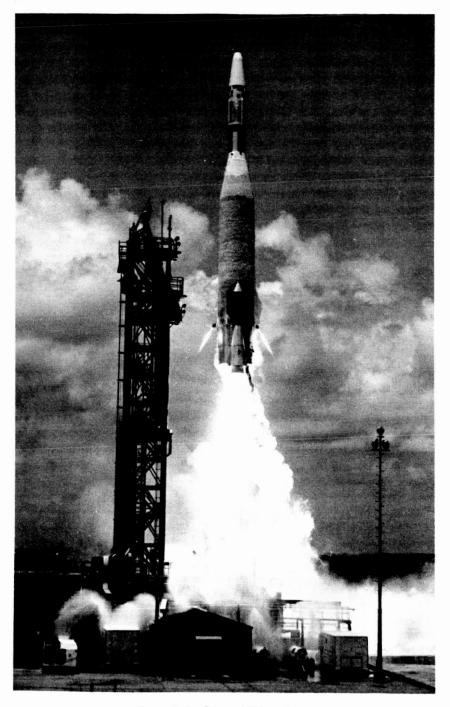


Figure 2-4. Ranger VII launch.

pictures of the Martian surface back to earth. Although considerably advanced technologically, Mariner IV is similar to Mariner II which performed the first successful planetary mission to Venus in 1962.

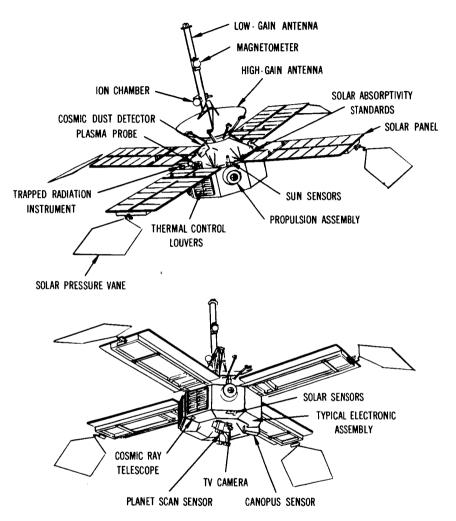


Figure 2-5. Mariner—Mars spacecraft.

#### Pioneer

Fabrication of the Pioneer prototype spacecraft was completed, and integration of its scientific experiments was underway. Experimenters were selected for the third and fourth flights in this series. Pioneer will measure magnetic fields, solar plasma, energetic particles, and cosmic dust.

#### Lunar Orbiter

In May 1964, NASA signed a contract for the development of Lunar Orbiter—the Nation's first satellite of the moon. Preliminary designs for the spacecraft and associated ground equipment were completed during this report period, and a critical review of the detailed design was scheduled for completion early in 1965. Thermal and structural development test models of the spacecraft demonstrated the reliability of the basic design concepts.

Primary objective of Lunar Orbiter is photographic reconnaissance of considerable areas of lunar surface to obtain topographic information needed to select landing sites for unmanned and manned spacecraft. For this purpose the satellite's cameras will expose and process photographic film, after which the images will be scanned electronically for transmission back to earth. As a secondary objective, the spacecraft will examine the moon's gravity field and space environment over an extended period of time. The first of the five missions authorized for the program was scheduled for mid-1966.

### Surveyor

Objectives of the Surveyor program are to soft land instrumented spacecraft on the moon, increase scientific knowledge of the moon by conducting experiments on its surface, and provide engineering and topographic data in support of manned lunar landings.

During this reporting period, substantial advances were made in developing the Surveyor spacecraft and its associated systems. Type-approval testing was successfully conducted on many subassemblies. System-functional testing of the prototype spacecraft was completed—including mission-sequence tests, radio-frequency interference tests, and tests to determine sensitivity to high-voltage electrical discharges. In addition, vibration testing of the spacecraft structure resulted in several improvements being incorporated into the spacecraft design. The controllable liquid-propellant vernier engines and the large solid-propellant main retrorocket were tested and found suitable. System-functional testing began on the first flight spacecraft. And, significant progress was also made in developing and testing scientific instruments for Surveyor's operational missions.

Planning continued for the follow-on (Block II) missions. Studies were completed on spacecraft configurations, payloads instrumentation, and the operational requirements for these missions.

## Planetary Studies

Studies continued of several possible concepts for future Mars missions following the 1964 Mariner launches. Flyby, orbiter, and

capsule-lander missions were evaluated for such launch vehicles as Atlas-Centaur, Saturn I-B Centaur, and Saturn V. These studies indicated that several mission possibilities appear to have considerable scientific value, and that those based on early use of Saturn I-B would, in the long run, afford the best results for the money spent.

Preliminary studies were also conducted on Jupiter, Mercury, moon, comet, and asteroid missions to estimate the mission profiles, spacecraft technology, and launch vehicle requirements for future space science programs.

# Bioscience Programs

Replying to a 1964 request from NASA for its views on the Agency's long-range goals, the National Academy of Sciences-National Research Council through its Space Science Board recommended that "unmanned exploration of the planet Mars, involving both physical and biological investigations and expressly the search for extraterrestrial life, be made the primary objective of the Nation's space effort in the 10 to 15 years following the Project Apollo manned lunar landing." This recommendation will receive consideration by NASA and other agencies involved in deciding the Nation's future space goals.

NASA initiated a study contract to develop a conceptual design for an automated biological experiment system to be carried on unmanned planetary spacecraft. The Agency also directed a broad-based, biological research program to supply vital data on the effects of the space environment on living organisms and on maintaining a man in space. This program will be supported by a biosatellite flight project of six recoverable orbiting biological satellites, with the first scheduled for launch in 1966.

# Exobiology

Automated Biological Experiment System.—A 1-year study contract was let in August to define mission objectives and establish a preliminary design for an automated biological experiment system able to search for and describe Martian life. The system, which would be able to operate for a 2-year period, could be carried aboard Voyager class spacecraft in the early 1970's when conditions will be favorable for missions to Mars. The combination of life-detection devices will have many advantages over several separate detection instruments, but present developmental efforts on separate life detection instruments such as the Wolf Trap, Gulliver, and Multivator will continue since they provide basic knowledge for the automated biological experiment system. In addition, the separate instruments

will be able to evaluate a specific aspect of the search for life when launched as additional payload aboard small spacecraft.

Wolf Trap Life Detector.—A proposed experiment to detect extraterrestrial life, the Wolf Trap, recently advanced to the engineering "breadboard" stage. Collaborating with Dr. Wolf Vishniac of the University of Rochester (New York), the inventor of the device, a NASA contractor developed the instrument package shown in figure 2–6. The device, which is about the size of a 7-inch cube, determines the presence of microorganisms when its culture broth becomes cloudy or undergoes acidity changes. Since bacteria are widely distributed and more readily found than more complex life forms, their presence on another planet (Mars, for example) may suggest the presence of advanced living systems. (See also the 11th Semiannual Report, ch. 2.)

Evidence of Organic Matter on Mars.—Dr. William M. Sinton of Lowell Observatory (Flagstaff, Ariz.) a few years ago obtained spectral features of Mars which suggested the presence of organic matter. These "Sinton bands" continue to be considerably difficult to interpret. Spectroscopists are attempting to resolve this problem. Dr. Sinton has joined Dr. Donald Rea (University of California,

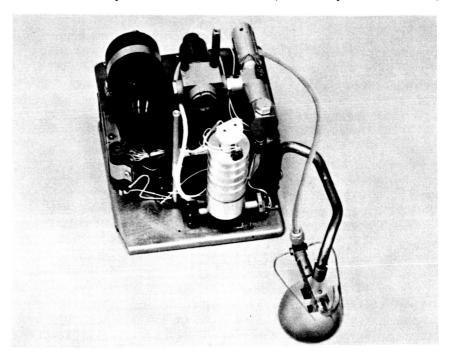


Figure 2-6. Wolf Trap engineering "breadboard" model.

Berkeley) in doubts about two of these three bands. Accordingly, Dr. Rea has designed a complex sensitive instrument, the Interferometer, for precise determination of fine spectral structure. The device (fig. 2–7) reunites separated light waves traveling over unequal optical paths and will be installed on a large earth-based telescope for use when Mars is relatively near the earth.

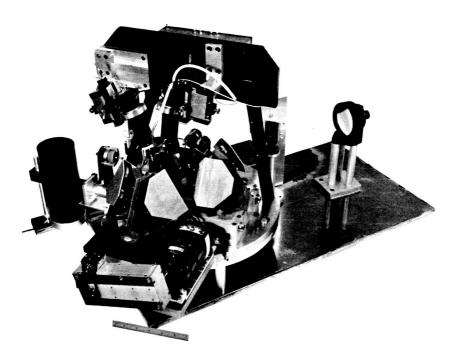


Figure 2-7. Interferometer.

# Planetary Quarantine

Since knowledge of the number and identity of organisms on space-craft hardware during assembly and after sterilization is basic to the sterilization process, several contractor laboratories, paced by NASA's Sterility Control Laboratory in Phoenix, Ariz., were seeking this information. The Phoenix laboratory is staffed by the Communicable Disease Center of the U.S. Public Health Service and operated under a contract with NASA.

The Communicable Disease Center at Atlanta, Ga., was also conducting research for NASA to define better methods of controlling biological contamination. Figure 2-8 shows equipment which meas-

ures the total number of organisms coming from a man confined in a specially designed tank. Results of this study will not only contribute to spacecraft sterilization techniques but should prove to be of value in surgical practices.

#### Biosatellites

Beginning in 1966, recoverable Biosatellites weighing 900 to 1,200 pounds will be launched by thrust-augmented Delta rockets into near equatorial orbits at altitudes of between 180 and 200 miles. Design of these orbiting biological laboratories was about 70 percent complete during this report period, and fabrication of experimental models of the heat shield and reentry capsule was completed by the prime contractor. Almost all program plans and specifications were also complete.

Sophisticated experiments to be carried aboard the Biosatellites were developed after several years of research. These 20 high priority experiments were carefully chosen from 185 submitted by scientists. Studies will be made of the effects of 3- to 30-day periods of weightlessness on the cells and tissues of various plants and animals. Experiments will be conducted on bacteria, gravity-sensitive plants, insects, amoeba, human cells, frog and sea urchin eggs, rats, and primates. Seven experiments will also be orbited for three days to investigate the effects of weightlessness combined with a radiation source inside the Biosatellite. Human cells in culture, plants, and rats will be flown for 21 days to determine the effects of weightlessness and removal from the earth's rotational influence. Pigtail monkeys with implanted deep brain probes and cardiovascular catheters will be orbited for a month.

These experiments were developed to the hardware stage and prototype hardware was being designed and tested for engineering and biological suitability. The Biosatellite studies will help pinpoint the hazards of space travel for astronauts and assist in determining and defining their effects on performance in manned space flight. For example, prolonged flights during weightlessness may involve changes in the cardiovascular system, loss of muscle tone and physical capability, and decalcification of the skeletal system, unless remedial measures are found.

# **Environmental Biology**

NASA continued its high priority laboratory experiments to prepare for the Biosatellite and other space flights. This research aims to determine the causes of problems which astronauts will experience when they are exposed to weightlessness and the other stresses of an

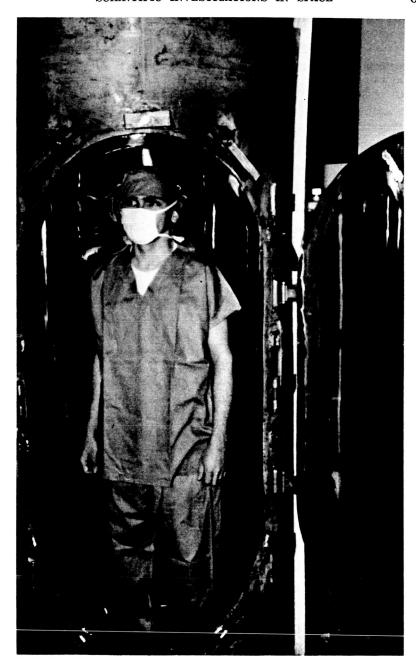


Figure 2-8. Biological cantamination control study.

ever increasing number of orbits in space. Bed rest studies of volunteer subjects during 2-week and 4-week periods of stimulated weightlessness were completed. Calcium loss of up to 10 percent from the heel bone was determined by X-ray densitometry; calcium and nitrogen losses in the urine were also greatly increased. Studies continued on the effects which an artificial space cabin atmosphere of 100 percent oxygen at low pressure might have on experimental animals. Helium gas as a substitute for nitrogen in the cabin appeared promising for use in manned spacecraft.

NASA grantees have made noteworthy progress in understanding how life can grow and exist in hostile and extreme environments. These scientists have developed a biological regenerative life support system combining the electrolysis of water and the activity of soil bacteria (Hydrogenomonas). The system uses electrolysis of fuel cell water and excess water of respiration of the astronaut to produce oxygen and hydrogen for the bacteria. In turn, the hydrogen, some of the oxygen, and the carbon dioxide and urine from the astronaut are used by the bacteria. Studies began on feeding these hydrogen-fixing bacteria to mice and human volunteers. Progress was also made in algal culture studies for use in life support when a month-old sterile recycled culture medium did not produce toxic products.

Efforts were also underway to decrease the human metabolic rate during long space flights in order to conserve food and the artificial atmosphere of the spacecraft. Hibernation and other methods of decreasing metabolic rates in a variety of animals were under study. A major effort was being made to determine how to induce hibernation and how to arouse hibernating animals.

# Behavorial Biology

Since most organs of the body show cycles of activity corresponding to the earth's rotation, removal of this influence in the course of space flight may produce changes during a 24-hour period. Princeton University scientists designed novel equipment to detect such changes in temperatures and activity in small organisms during orbital flight. At the University of Kentucky Medical School, the effects of geophysical factors on primates (such as gravity and magnetic forces on biological rhythms) were being investigated.

Noteworthy advances were made in developing an apparatus and techniques to study brain-behavior relationships in a project spousored by NASA and the National Institutes of Health. A brain stimulator-monitor system was being developed which is able to transmit radio signals to stimulate an animal's brain and also verify receipt of these signals. The system can telemeter electrocardiograms, electro-

encephalograms and respiration data, and transmit to and from an animal without restraining or restricting its activity. A system of this type being used by the National Institute of Mental Health is shown in figure 2–9. It features a miniaturized solar panel on the animal's head serving as a source of power for stimulation and telemetry.

Future research may employ biological fuel cells to supply electrical energy in these brain stimulator-monitor systems. Instruments will explore the possibilities of manipulating various forms of behavior important for survival by electrical stimulation of specific areas of the brain through carefully placed electrodes. Sleep, alertness, hunger, and satiation may also be induced artificially.



Figure 2-9. Brain stimulator-monitor system test.

# Physical Biology

Bioscientists were investigating the use of certain animals in space flight experiments. For example, the tiny mouse (*Perognathus*) is uniquely suitable for these experiments because it weighs less than half as much as the laboratory mouse, requires no water intake, and can hibernate readily when its environmental temperature is varied

or its food supply decreased. This species also lends itself to studies of day-night activity cycles.

In another investigation on the effects of weightlessness and other space stresses on the circulatory system, a mechanism was observed which seemed to control human blood vessel and capillary activity in regular 2-minute cycles. Studies were underway to determine how these normal rhythmic cycles will be affected by weightlessness and disease.

#### Manned Space Science

Preparations for manned exploration of space continued on a nationwide front as NASA, in October, announced the opening of scientist-astronaut recruitment. On the basis of standards set up by the National Academy of Sciences and the Agency during 1964, and subsequent screening of applicants by the Academy, NASA expects during 1965 to select 10 to 20 trainees from over 1,000 applicants. Astronauts now in the manned space program studied space sciences at the Manned Spacecraft Center, at observatories, and at sites in the Western United States similar in topography to possible lunar landing areas. This training will improve their ability to make scientific observations in space and prepare them to carry out preplanned investigations on Gemini and Apollo missions.

Apollo Lunar Science.—In university and other research facilities, geologists, geochemists, geophysicists, atmospheric scientists, bioscientists, nuclear physicists, astronomers, solar physicists and engineers were planning investigations to be conducted by astronauts on the moon. On the basis of information supplied by these scientists, a variety of instruments were being designed for manned investigations. These include seismometers, gravimeters, radiometers, and geological handtools and other surveying equipment. A built-in versatility in basic instrumentation will enable scientists who have limited engineering assistance to participate fully in planning lunar exploration. At the same time, participating scientists may develop any unique equipment required by their experiments, as many are doing in other space science flight programs.

The Manned Spacecraft Center awarded a contract for the completion of a study and design of a small, portable thermonuclear generator to provide a 1-year power supply for instruments which will be left by astronauts on the moon. Another contract awarded by the Center marked the final step in defining a telemetry system able to transmit data to the earth from these lunar-based instruments after the astronauts have returned.

Gemini and Apollo Earth-Orbital Experiments.—The development of scientific investigations—approved earlier in 1964 to be carried out as part of Project Gemini—was well advanced by the fall of 1964. Flight hardware for experiments scheduled for the first manned Gemini flight was delivered to the spacecraft contractor for installation. Remaining developments were on schedule, as scientists and engineers at the Manned Spacecraft Center worked closely with the principal investigator for each experiment.

Responding to a June notice that Apollo earth-orbital missions before the lunar landing would be able to accommodate experiments, scientists proposed nearly 50 investigations for these missions. Three of these proposals were selected as space science experiments by NASA and awaited their assignment to specific flights by the Agency at the close of 1964. Other investigations were expected to be approved early in 1965. Development of these experiments will continue into 1967.

Advanced Scientific and Applied Missions.—As a result of growing interest in potential manned space flight applications on the part of the Departments of Agriculture, Commerce, Defense, Interior, and Health, Education, and Welfare, NASA entered into negotiations with these agencies to establish cooperative study programs involving the possible contributions of earth-orbiting manned missions to forestry, natural resources (mineral and water), weather forecasting and modification, crop surveys, and air pollution.

NASA also continued studies of manned space missions as potential laboratories for the investigation of space effects on materials and organisms; as platforms for remote-sensing investigations using infrared, ultraviolet, visual light, radar, and other telescopic or electronic instruments; and as bases for field studies of the space environment.

Man's Scientific Role in Space.—The scientific and applied roles of man in space, regardless of the scientific disciplines involved, appear to depend on four broad classes of human ability (fig. 2-10). The first of these is man's ability to observe (to be a sensor); the second his motor and manual skill (to be a manipulator); the third his ability to intelligently consider (to be an evaluator); and finally his ability to combine these three to become an active, creative investigator. (The ability to communicate is a recognized element of all four classes.) In addition to acquiring data on space science, a major goal of scientific investigations on early manned space missions will be to determine to what extent men can employ these abilities effectively during space flight missions.



Figure 2-10. The role of man in space.

# Light and Medium Launch Vehicles

NASA used Scout, Delta, Agena, and Atlas-Centaur vehicles to launch spacecraft in its space science and applications programs.

#### Scout

Eight Scout vehicles were successfully launched during the period: SERT, ion engine (July); thermal protective materials reentry experiment (August); Ionosphere Explorer XX (August); Atomic Energy Commission reentry experiment (October); Beacon Explorer XXII (October); Micrometeoroid Explorer XXIII (November); Air Density and Injun Explorers XXIV and XXV (November); and the Italian-launched San Marco I (December).

#### Delta

Launch operations of Delta vehicles were resumed in August after the inadvertent ignition of a third-stage Delta motor in April was investigated. Cause of this accident was established as electrostatic discharge and suitable steps were taken to prevent a recurrence. (*Eleventh Seminannual Report*, ch. 2.)

On August 19, Syncom III—the world's first geostationary satellite—was successfully orbited by a Delta vehicle. Another Delta, on October 3, failed to place the Interplanetary Monitoring Platform Explorer XXI into the planned orbit; as a result the spacecraft did not accomplish all its objectives. And, on December 21, this launch vehicle successfully orbited an energetic particles satellite—Explorer XXVI. Delta vehicles at the close of this report period had made 23 successful launches in 26 attempts.

# Agena

Ranger VII Launch.—An Atlas-Agena vehicle launched Ranger VII in late July. The spacecraft impacted the moon after obtaining excellent quality pictures of the lunar surface. (This flight is detailed on p. 55.)

Nimbus I.—A Thor-Agena launch vehicle combination successfully placed Nimbus I into a polar orbit in late August. Although the orbit was eccentric rather than circular, the spacecraft obtained excellent photos of weather formations.

OGO-I.—The first Orbiting Geophysical Observatory was launched by an Atlas-Agena in September. The planned trajectory and velocity were achieved and the satellite separated from the launch vehicle as

planned. Experiments aboard the spacecraft were transmitting data during this report period.

Mariners III and IV.—Atlas-Agena vehicles launched two spacecraft in November to photograph Mars. The first, Mariner III launched November 5, could not be injected into a Mars approach trajectory. Mariner IV was successfully launched on November 28, and its experiments were operating as designed. (Both Mariners are discussed on pp. 55–57.)

Standard Atlas Development.—The NASA/Air Force standard Atlas improvement program was essentially completed during the last 6 months of 1964. This standardized Atlas vehicle will eventually be used for all NASA and Air Force programs in the Atlas-Agena payload class. The first two of these vehicles were launched by the Air Force in the third quarter of 1964. Test results indicated both vehicles were successful. The first NASA use of the vehicle is scheduled for 1965.

Agena Improvement Program.—The NASA/Air Force Agena improvement program was also successfully completed during this period. NASA's first use of the improved Agena D was the launching of Mariners III and IV. The improved vehicle allowed a payload increase of at least 80 pounds.

Launch Vehicle Status.—Atlas-Agena and Thor-Agena vehicles were being prepared to launch another lunar photographic mission, a second Orbiting Geophysical Observatory, an Orbiting Astronomical Observatory, a weather satellite, and a Lunar Orbiter during 1965 and early 1966.

#### Atlas-Centaur

Atlas-Centaur, the Nation's first launch vehicle to use liquid hydrogen fuel, was under development for lunar and planetary explorations. Its first assignment is to carry Surveyor spacecraft to soft land on the moon

Four development vehicles have been tested: The first flight in May 1962 failed; the second and third flights were generally successful; and the fourth vehicle, launched on December 11, carried a mass model of a Surveyor spacecraft in a test which achieved all primary mission objectives. Although an attempt to restart the Centaur engine in flight did not succeed, the metal Surveyor model was placed in a precise orbit.

Development of this initial "direct ascent" vehicle will be completed in 1966 and one readied for the first Surveyor mission. A parking orbit capability will be provided during 1966 and additional payload capacity in 1967.



# SATELLITE



Marking a distinct advance over earlier communications satellites, NASA's Syncom III—the world's first geostationary satellite—relayed TV coverage of the Tokyo Olympic games to the U.S. Over 50 million Europeans later viewed many of these televised events via NASA's Relay spacecraft.

In meteorological programs, Nimbus I provided improved cloud cover pictures during the day, and the satellite's new infrared radiometer supplied TIROS-quality cloud pictures at night. Further, by the end of December, the eight TIROS spacecraft had supplied more than 400,000 cloud cover pictures—the vast majority of them useful to weather analysts and forecasters.

# Meteorological Programs

Satellites in the TIROS series continued to set new longevity records and to furnish an increasing ratio of meteorologically useful photographs to the total transmitted.

In addition to substantially improved global cloud pictures provided by an Advanced Vidicon Camera System, the first Nimbus supplied limited cloud cover data to local stations from its Automatic Picture Transmission subsystem. Nighttime cloud cover information was provided by a High Resolution Infrared Radiation subsystem.

Also during the report period, meteorological sounding rockets were launched from shipboard for the first time.

#### **TIROS**

The extended useful lifetime of TIROS spacecraft was demonstrated during the last 6 months of 1964 by the continuous operation of the seventh and eighth in the series. TIROS VII, orbited June 19, 1963, completed over 18 months of operation with all major systems functioning and was still providing valuable data. TIROS VIII, launched December 21, 1963, continued to provide good quality pictures from its TV and recording systems. The Automatic Picture Transmission (APT) subsystem was first flight-tested aboard TIROS VIII. Although the TIROS spacecraft were designed for a lifetime of three months, all but the first of the series exceeded this time.

The eight TIROS satellites have provided more than 400,000 cloud cover pictures; over 80 percent proved to be extremely useful to weather analysts and forecasters. As of December 31, 1964, these photographs were used as follows:

Cloud cover analyses	12,736
Special satellite storm advisories	1,494
Miscellaneous satellite bulletins	
Improvements to weather analyses	
Hurricanes observed	
Typhoons observed	

Since TIROS VII and VIII and Nimbus I were in orbit at the same time during the 1964 hurricane season, this storm period was the most closely observed in history. The very destructive storms Cleo and Dora which struck the southeastern United States were first observed by these satellites (fig. 3-1), and satellite cloud cover pictures played a substantial role in subsequent tracking of these storms.

The next spacecraft in the TIROS series will be built to operate like a cartwheel. This TIROS I (Eye) will be the first spin-stabilized meteorological satellite and will be able to provide global daylight cloud cover data daily because it will be in a near-polar orbit. The spacecraft will roll like a wheel along its orbital path so that its cameras, aimed radially outward from the center, will take pictures when they are looking straight down at the earth. During the report period, testing and qualification of the spacecraft were completed, and plans were made for launching early in 1965. (This satellite—orbited on Jan. 22, 1965, as TIROS IX—proved to be highly successful.)

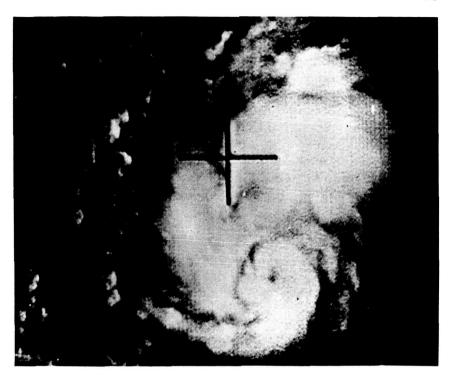


Figure 3-1. Hurricane Cleo photographed by TIROS VII.

NASA will develop and launch the Weather Bureau's TIROS Operational Satellite (TOS) system based on the cartwheel design. Two types of spacecraft will be used in the initial systems. One will carry two Automatic Picture Transmission subsystem cameras to provide direct local readout of cloud cover data; another will use two Advanced Vidicon Camera Systems, including tape recorders, which will furnish global cloud cover data to be read out at the Command and Data Acquisition Stations. Both camera systems were developed for Nimbus. In combination they will meet the minimum requirements of agencies using these meteorological data by providing them with full daylight global cloud coverage and direct readout by local stations during daylight. However, the initial systems will eventually need to provide data at night along with cloud top measurements and to obtain certain radiation measurements. Work progressed toward satisfying such additional requirements and the more stringent ones of a fully operational system—a cooperative NASA-Weather Bureau program.

#### Nimbus

Nimbus I was launched on August 28 into a sun-synchronous, nearpolar orbit with an apogee of 597 miles, a perigee of 272 miles, and a period of 98.3 minutes. Although its orbit was more elliptical than the planned 575-mile circular orbit, all of its systems operated and its sensors provided data throughout the spacecraft's active lifetime of 3½ weeks. The spacecraft carried a stabilization and control system which kept its sensors pointed earthward at all times. This contrasts with the TIROS satellites which are space-oriented—pointing to the earth only part of the time.

Performance of the Automatic Picture Transmission (APT) subsystem was excellent (fig. 3-2). This subsystem used simple, relatively inexpensive ground stations to receive cloud cover pictures of local areas directly from the satellite. The first APT photographs The following day two were transmitted about 9 hours after launch. passes of the satellite were recorded by a single simple ground station. One pass, recorded by Goddard Space Flight Center, covered a 3,000mile-long strip from Venezuela to Canada, and the other pass was nearly as long. Together the passes spanned one-eighth of the eastto-west direction around the world. Ideally there would be three passes—one as the satellite passed overhead and one each as the spacecraft passed to the east and west of the station. More than 60 APT ground stations throughout the world are operated by this country, by foreign governments, and by some private concerns. Canada, France, England, Federal Republic of Germany, Switzerland, Denmark, Argentina, Brazil, Australia, Indonesia, and India were the other countries participating in the Nimbus program.

Since Nimbus was launched into a more elliptical orbit than desired, its Advanced Vidicon Camera System could not provide the planned overlapping global daylight cloud cover data to Command and Data Acquisition Stations. The extent to which these data were supplied, particularly at the highest point in the spacecraft's orbit, is shown by a picture of Western Europe taken by this camera system (fig. 3-3).

In addition to the two camera systems to take pictures in daylight, Nimbus I carried a high resolution infrared radiometer which supplied cloud cover data of the dark side of the earth for the first time. This sensor indirectly measured the temperature of the surface of the earth and that of cloud tops. Knowledge of the rate of decrease of temperatures with increasing height allowed estimates to be made of the height of the clouds. The quality of these photographs is equivalent to that of the TIROS pictures. Individually framed pictures are not obtained, but rather a continuous strip of pictures is taken as



Figure 3-2. Nimbus photographs England, France, and Spain.

the satellite moves forward. The illustration (fig. 3-4) shows a small section of an east-west scan path of this radiometer through Hurricane Gladys in September. Many scans were needed to reproduce the entire picture.

After 3½ weeks of operation, a mechanical failure stopped the solar panels of Nimbus I from rotating to face the sun, reducing the power received so that minimum satellite activity could not be maintained. Because no signals were received from it on September 23, the satellite was considered to have stopped functioning. During this report period, test and development work was undertaken to prevent similar failures in future Nimbus spacecraft. The following sensory data were obtained from Nimbus I during its 3½-week lifetime:



Figure 3-3. Western Europe as seen by Nimbus I.

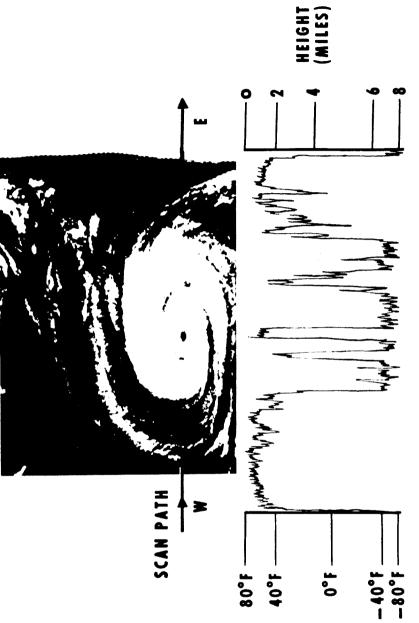


Figure 3-4. Pictorial reconstruction of Hurricane Gladys from Nimbus radiometer measurements.

# Meteorological Sounding Rockets

NASA launched 45 small meteorological rockets from Wallops Island, Va., to test various types and obtain meteorological information for range support and research. In addition to flight testing its small meteorological sounding rockets, the Agency carried out evaluation of antenna patterns, power supply, oscillator performance, temperature calibration, and payload performance of Arcas-type rockets under simulated flight conditions.

During July and September, parachute performance flights were conducted at White Sands Missile Range (N. Mex.); recoverable camera packages were used to record deployment, opening, and descent characteristics of several types. A despin device for the payload package was under consideration and study as a result of these flights.

Twenty-seven of the 30 large meteorological sounding rockets launched during the period were successful. Among other large sounding rocket experiments were 13 coordinated launches in August from Wallops Island, Va.; Fort Churchill, Canada; Ascension Island; and Kronogård, Sweden, to provide information on the geographical variation of the atmospheric structure during the summer.

In November, four grenade experiments and six sodium vapor experiments were launched to make various measurements of the atmospheric structure during the autumn. Three of these sodium vapor experiments were launched from shipboard off the eastern coast of the United States at the same time that similar experiments were launched from Wallops Island. This was the first such launch from a ship.

Plans were made for atmospheric exploration to continue in 1965 with coordinated launches from Wallops Island, Fort Churchill, and Ascension Island. Additionally, in January, grenade experiments will be conducted from Point Barrow, Alaska, to determine the structure of the atmosphere during the period of continuous darkness in the Arctic. These will be coordinated with launches from Wallops Island and Fort Churchill. During the first quarter of 1965 there will also be eight pitotstatic tube experiments launched from shipboard in the western portion of the South Pacific Ocean to determine the structure and variation of the atmosphere in the Southern Hemisphere. Small meteorological sounding rockets will also be launched to provide a more complete profile of the atmospheric structure.

# Global Meteorological Observation System

At the Fourth Congress of the World Meteorological Organization, held April 1963 in Geneva, studies were authorized of approaches to a global observation system based on meteorological satellites. During the report period, NASA was proceeding with research and development for its Interrogation, Recording, and Locating Subsystem to be flown aboard Nimbus spacecraft. A joint technical meeting was held at Goddard Space Flight Center in November with French scientists planning a similar satellite experiment.

# Communications and Navigation Programs

NASA experimented with seven orbiting communications satellites, as Syncom III joined Syncom II, Relay I and II, Telstar II, and Echo I and II in space.

Syncom III, launched in August, is the world's first geostationary satellite. It relayed TV coverage of the Olympic games from Japan to the United States and served as a research and development operational communications link for the Defense Department.

On December 31, NASA agreed to phase over control of Syncom II and III to the Defense Department between January 1 and April 1, 1965. However, NASA will continue to control demonstrations by the satellites, reduction of certain scientific data supplied by them, and completion of and reporting on this communications project.

Telstar II continued operating successfully during its second year in orbit; Relay I exceded its design lifetime of 1 year by an additional year; and Syncom II provided over 4,000 hours of successful experiments in 17 months of operation.

The Agency also entered into an agreement with the Communications Satellite Corp. to provide launchings and related support services on a reimbursable basis for the Corporation's early experimental-operational global communications system. (Described in detail in the *Eleventh Semiannual Report*, ch. 3.)

#### Active Communications Satellites

Syncom III was launched on August 19 and achieved a synchronous orbit with zero inclination. As a result the spacecraft "hovers" over a point on the Equator instead of describing a figure 8 as the second Syncom does. (Fig. 3-5.) The spacecraft was caused to drift eastward from its initial station until it reached the International Date Line, where it was stopped on September 11. Since launch, Syncom III conducted experiments for many hours daily and served as a research and development operational communications link for the Department of Defense (DOD). The spacecraft also relayed TV coverage of the Olympic games to the U.S. from Japan, in October, and later supplied telecasts of these events to over 50 million European viewers via NASA's Relay satellite.

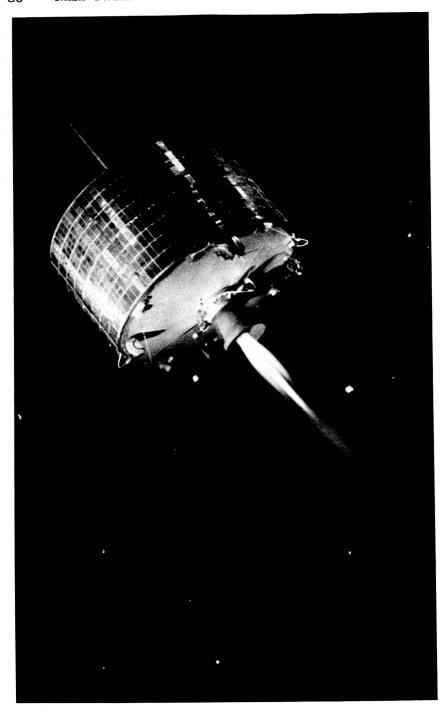


Figure 3-5. Syncom III spacecraft.

Communications tests with Syncom II, launched July 26, 1963, continued, and more than 4,000 hours of actual communicating time were logged as the spacecraft well exceeded its designed lifetime. At the request of the DOD, Syncom II was moved in March from its position over Brazil by a command to drift westward at a rate of 1.3 degrees daily. In April, its drift rate was slowed to 0.8 degree a day, and by about mid-February 1965, it will be in the desired position over the Indian Ocean where it will be stopped and positioned.

Telstar.—Orbited May 7, 1963, Telstar II continued to operate satisfactorily, completing 1½ years of operation without significant difficulty other than a period (July 16-Aug. 12, 1963), when it refused to respond to commands. Numerous public demonstrations have taken place via this Telstar, including communications experiments linking Europe with North America.

Relay.—Relay II, launched on January 21, 1964 from Cape Kennedy, has operated as planned for over 330 hours, performed more than 1,600 experiments, and conducted at least 100 technical and public demonstrations. A number of changes and improvements were incorporated into its solar cells, power supply circuitry, command circuitry, traveling wave tube, and radiation detectors. These changes, partly based on experience with Relay I and Telstar I, contributed to its longer life and more efficient operation. Two new ground stations joined the Relay network during this report period: A station in Rao, Sweden, operated cooperatively by Sweden, Denmark, and Norway, and a West German wideband station near Raisting. NASA also signed an agreement with India for the government of that country to establish a narrowband station near Ahmedabad in 1966.

Relay I, launched December 13, 1962, continued to exceed its designed lifetime of 1 year. An onboard timer failed to turn off the satellite in December 1963, and is not now expected to do so.

#### Passive Communications Satellites

The launching of Echo II on January 25—a large rigid reflecting sphere used as a passive communications satellite—was described in the *Eleventh Semiannual Report*, (ch. 3).

As reported at that time, the sphere started spinning shortly after inflation at about 0.6 r.p.m. This spin distorted the satellite, causing a fluctuation of the strength of signals reflected from it. Investigators tentatively concluded that the spin was caused by pressurizing gas leaking out through a small unsymmetrical tear in the sphere. Echo II was used by the Air Force for communications experiments between Rome, N.Y., and Puerto Rico, and under NASA's sponsorship, for experiments between a contractor facility near Dallas, Tex.

and a Navy station at Stump Neck, Md. In addition, Soviet sciennists, in cooperative experiments with this country under the bilateral agreement of August 1962, reported optical observations and communications test data. Several of their original film negatives in studies of early orbit behavior were sent to NASA for analysis.

Echo I (launched Aug. 12, 1960) was still orbiting. Its utility as a communications link was limited because it was wrinkled and no longer spherical. However, the satellite was used in geodetic investigations by various organizations through simultaneous photography from several widely spaced stations.

#### Navigation Satellites

Studies of the feasibility of using satellites as an aid to air and sea navigation, traffic control, and rescue activities were completed during the first half of 1964 (Eleventh Semiannual Report, ch. 3). NASA concluded from these studies that a satellite could provide such services continuously on a worldwide basis, during all weather conditions, for craft ranging from supersonic transports to small oceangoing vessels. Accordingly, NASA invited the Departments of Treasury, Defense, Interior, and Commerce, and the Federal Aviation Agency to join in forming an ad hoc Joint Navigation Satellite Committee. During this report period, these agencies agreed to serve on the committee which began to evaluate the requirements for a satellite system to meet future air and sea navigation and traffic control needs; determine if such a system is in the national interest; and recommend an appropriate program of research and development for each participating organization.

Progress was made in planning experiments to be incorporated in NASA's Applications Technology Satellites, which are designed to demonstrate the feasibility of certain navigation satellite hardware by flight testing promising new techniques.

# Applications Technology Satellites

The Advanced Technological Satellites Program—described in the Tenth and Eleventh Semiannual Reports—was renamed the Applications Technology Satellites (ATS) program. The ATS project, managed by Goddard Space Flight Center, will investigate, develop, and flight test equipment which promises to be useful in a number of applications. It will include studies of higher gain antennas and passive gravity gradient stabilization methods, and flight experiments in communications, meteorology, and navigation.

An ATS flight series was planned for late 1966. It will include experiments in passive gravity gradient stabilization at a 6,500-mile altitude, in wideband communications, and in measuring radiation in space. (Fig. 3-6.) A total of five flights were planned—four at synchronous altitude.

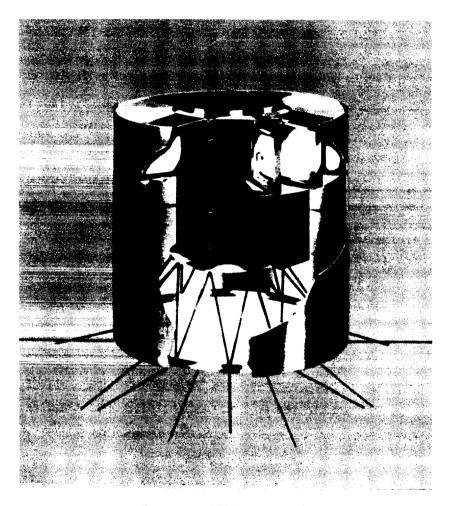
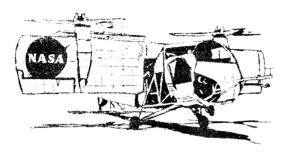


Figure 3-6. ATS basic spacecraft.

4

# ADVANCED RESEARCH AND TECHNOLOGY



NASA's Office of Advanced Research and Technology has the responsibility for some 2,400 of its own individual tasks in basic research, engineering research, and experimental subsystem technology. The research program is conducted primarily at the five research centers under the supervision of the Headquarters staff, with many investigations carried on by universities or industrial organizations under contract. In addition, this office is responsible for reviewing the 1,400 or more supporting research tasks of the other NASA Program Offices to assure a balanced and effective overall Agency effort. OART is also responsible for the implementation and operation of the Agency's part in the NASA-DOD Research and Technology Information Exchange.

Progress made during the period of this report, as discussed in the following pages, reveals both the wide range of activities engaged in by this office and the close relationship of its work to the overall mission of the Agency.

# Space Power Technology

The solar and chemical power program, which is concerned with the application of solar and chemical energy for spacecraft electric power systems, includes over 100 tasks ranging from basic research through component development and feasibility demonstrations of complete systems. Its objective—to enhance the technical capability to harness chemical and solar energy for electric power—will provide the technology needed to support expanding future programs.

#### Solar Cells

To obtain updated standards, solar cells were mounted on test assemblies and sent aloft atop balloons to 80,000 feet where less than 1 percent of the earth's atmosphere remains between the cells and the sun. Solar cells output was measured, the balloons returned to earth, and the cells were recovered. They will serve as solar intensity standards in solar simulator and terrestrial sunlight measurements of the capability of solar cells and solar arrays to produce power.

Also, Nimbus I (discussed in ch. 3, p. 74) used about 11,000 of the more radiation resistant reverse structure n on p silicon solar cells.

Work continued on packaging and deploying large area solar cell arrays. An investigation was started of the feasibility of supporting silicon solar cells (now 0.008 inch thick and 50 percent lighter than formerly) on plastic (H-film) substrates; this work will be continued. Also, the strength of the metallic contact to gallium-arsenide solar cells was improved; these cells offer the potential advantage of being able to operate reliably up to 250° C., whereas silicon cells are limited to about 125° C. And efforts to improve solar cell resistance to radiation damage progressed with experiments to identify the effect of resistivity, junction depth, and impurities on damage rate.

#### Thermionics

The design of an advanced thermionic generator incorporating four series-connected converters was completed, and generator and converter fabrication was started. Converters of the type to be used in this generator showed more than 25 percent improvement over those used in tests discussed in NASA's Eleventh Semiannual Report (p. 92). Research continued on the effect of emitter material, material preparation, collector material, interelectrode spacing, and additives on converter power density, output voltage, and efficiency. Finally, in the first tests of a multiconverter thermionic generator using solar energy, a power output  $2\frac{1}{2}$  times that developed in previous tests was achieved.

#### Solar Energy Collection and Storage

Practical and useful solar power systems which convert heat (thermal energy) to electricity depend on the development of light-weight solar concentrators (collectors) having a high degree of geometrical concentrating ability and a durable, mirrorlike, reflecting surface. Another requirement is the ability to store thermal energy so that power can be generated when sunlight is not available.

Progress was made in developing aluminum electroforming processes for fabricating lightweight, high-performance, nonmagnetic solar collectors. Production of 30-inch-diameter protype models with good structural geometric characteristics demonstrated that large-scale aluminum electroforming is practical. Also, a vacuum separation technique was developed for low stress removal of thin-walled, accurate electroforms from the master.

In research on thermal energy storage materials, essential new information was obtained about the thermophysical properties of lithium fluoride (one of the pricipal materials under consideration for the solar-Brayton cycle system) and its long-term compatibility with candidate containment materials. Techniques for preparing, handling, and studying a beryllium-magnesium oxide mixture (the material being considered for the solar thermionic system) were developed sufficiently to permit reproducible thermal cyclic tests for up to 1,000 hours, using rhenium as the containment material. This work is the first step in obtaining the basic information required to develop the thermal energy storage capability for solar-thermal systems.

#### Batteries

In efforts to develop a primary (not reusable) battery capable of delivering 200 w.-hr./lb. (watt-hours per pound), an experimental cell produced 125 w.-hr./lb. or about 40 percent more than the best conventional system. A new experimental high-temperature power pack was run for 6 days at almost 30 w.-hr./lb. output. This development is a considerable improvement over the high-temperature batteries which have been usable for only minutes, and may make it possible to obtain electrical power on the surface of Venus. A hybrid battery/fuel cell was refined by encapsulating the electrolyte, switching from conventional to high-energy-density chemicals, and designing a motor and movement to feed the dry tape through the current collectors using only a small fraction of its own power output.

#### Fuel Cells

Tests of high performance fuel cell electrodes that will fit existing fuel cell systems indicated that fuel cell efficiencies might be increased by at least 10 percent; such a development would lower the weight of the total system or extend mission time with a concomitant decrease in the heat load on the radiator.

A low-temperature, 1.8 kilowatt hydrogen-oxygen fuel cell was operated for over 500 hours on a typical spacecraft power profile. The system was being modified so that part of the product water can be collected for onboard use and excess water can be ejected and used for cooling.

#### Brayton Cycle Investigation

Aerodynamic efficiency tests on a 6-in.-diameter radial-flow turbine and compressor in the Reynolds number range (approximately 60,000 to 200,000) associated with the 10-kw. power level indicated better-than-predicted efficiencies. Fabrication of gas-bearing-supported radial-flow turbo-compressor units and of axial-flow turbines and compressors for aerodynamic efficiency tests was started; preliminary design of gas-bearing-supported turbo-alternator and turbo-compressor units was initiated; and tests were begun to obtain aerodynamic performance characteristics of radial-flow turbines and compressors in the very low Reynolds number range (approximately 30,000) associated with low power (1 to 3 kw.). Also during this time, stands for performance and operational testing of the gas-bearing-supported machines and the regenerator were being erected at Lewis Research Center.

# **Electrical Systems Technology**

To enhance performance and reliability of space electrical power systems, development continued on battery charge control techniques; power distribution components such as switches, relays, and circuit protective devices; and improved circuitry for d.c. to a.c. inversion, d.c. to d.c. conversion, and voltage regulation. Static inverters and converters were operated in parallel under widely varying steady state and transient conditions; these devices will provide greater flexibility of system design and higher system reliability for a given weight. An improved battery charge control system for satellites was developed permitting fuller use of the batteries through closer monitoring of the battery state of charge and improved techniques in controlling recharge.

# Space Vehicles Program

#### Lifting Body Spacecraft

The flight program of the lightweight Ames M-2 vehicle (fig. 4-1), was completed. The results show that man can safely fly and land a lightweight, lifting bodytype spacecraft. aBsed on the promise shown by the lightweight vehicle, two vehicles with realistic spacecraft weights (discussed in detail in NASA's Eleventh Semiannual Report pp. 93-95) were on order. Design of both vehicles was completed, and fabrication of the M-2 vehicle was well underway with delivery expected in the first half of 1965.

# Large Parachute for Spacecraft Recovery

Research continued at the Manned Spacecraft Center on safe and reliable means of recovering manned spacecraft. Heavy spacecraft (weighing about 10,000 pounds) now require multiple parachutes, with attendant high-stowage volume and weight, for landing of spacecraft and astronauts. A single, more reliable large parachute was developed which is capable of recovering a 10,000 pound spacecraft.

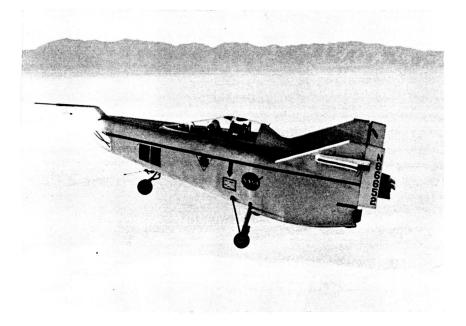


Figure 4-1. M-2 vehicle in flight.

#### Thermal Radiation

The effect of heat shield material on thermal radiation was studied in the hypersonic free-flight facilities at the Ames Research Center. The tests showed that the thermal radiation from some plastics was much greater than from other plastics or nonplastic materials. For example, one plastic, polycarbonate, gave off seven times more thermal radiation than a nonablating material on a model at a speed of about 15,000 m.p.h. It was found that ablating plastics exhibiting this radiation contained very little oxygen in terms of carbon present, or were oxygen poor. On the other hand, plastics containing as many oxygen as carbon atoms or more oxygen than carbon atoms did not exhibit this thermal radiation effect. These data may be applicable to the development of future heat shields.

# High-Energy Radiation Shielding

The ability of various materials to shield against high-energy protons was investigated by the Oak Ridge National Laboratory, under NASA contract. At the University of Chicago, experimental measurements were made to determine the emission of secondary protons and neutrons produced by 450 Mev protons in several materials. Theoretical calculations of the X-rays produced by high-energy electrons in thick target materials were performed by the National Bureau of Standards and compared with experimental data. The results indicated that for electrons from a few Mev down to very low energies and for materials of low atomic number, the available theory is adequate for most engineering applications; however, cross-section input data should be improved.

# Meteoroid Environment and Impact Hazard

A recoverable meteoroid probe (paraglider) was launched from White Sands Proving Grounds to an altitude of 600,000 ft. to sample the flux of small particles in the upper atmosphere during a meteor shower. Data obtained were being analyzed.

To provide controlled data on luminous efficiency of simulated meteors, another artificial meteor experiment was conducted (Eleventh Semiannual Report, p. 96). Two iron meteors were simulated—one a single particle and the other an aggregate of smaller particles. The data obtained on these particles as they entered the atmosphere were being studied.

Another satellite of the S-55 series, launched November 6, 1964, and designated Explorer XXIII, investigated meteoroid penetration of thin pressurized cans. (Fig. 4-2.) Through the first 16 days in orbit six penetrations were recorded.

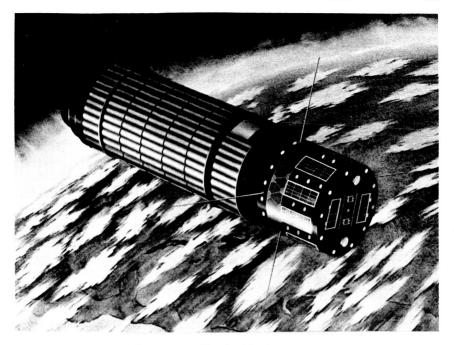


Figure 4-2. Sketch of Explorer XXIII.

## Zero-Gravity Fluid Behavior

The Lewis Research Center continued an overall study of problems associated with the behavior of rocket engine propellants stored in space vehicle tanks under conditions of weightlessness. One particular aspect, the effect of propellant outflow on the behavior of the liquid-vapor interface (boundary), was investigated experimentally using a cylindrical tank in a drop-tower facility. Photographs indicated that the liquid-vapor interface configuration during outflow can be significantly affected by propellant outlet velocity and the distribution of incoming pressurized gas. When an inlet deflector and an outlet baffle were used at the same time, there was minimum interface distortion and maximum liquid expulsion, both desirable effects.

# High-Vacuum Technology

Although the ability to produce pressures comparable to that in outer space (about 10<sup>-14</sup> mm. of mercury) is being developed, techniques to measure such low pressures or gas densities are severely limited. In efforts to resolve the measurement problem, a contractor completed a study of gage performance with the following results: an advanced method of calibrating gages to very low pressures (3x10<sup>-13</sup>

mm. of mercury) using a special pressure ratio technique was developed; two new gages incorporating changes to reduce current leakage and to increase current detectability showed superior performance under test; and the effect of a gas beam on a particular exposed gage was found to be independent of incidence angle.

#### Thermal Radiation and Temperature Control

Electroluminescent panels to automatically control the rate of absorption of solar energy by spacecraft surfaces were subjected to laboratory tests. They showed large increases in luminescence accompanied by increased solar energy absorption when the frequency of an applied voltage was varied.

Research was conducted on highly reflective white paints for passive control of the temperature of liquid hydrogen storage tanks on the moon. It was found that the deposit of a thin uniform layer of fine particles on the paint impaired its usefulness for temperature control. This finding must be considered in the design of lunar roving vehicles, for a layer of lunar dust may affect the thermal balance characteristics of their radiators and other surfaces.

### Space Vehicle Structural Loads

In research on ways of absorbing the impact energy developed in the landing of a spacecraft, a study was completed of a new concept which embodies multiple cycling of materials into the plastic strain range (where relatively large deformations can occur without failure). One technique involves rolling a laterally-compressed tube so that individual fibers are alternately compressed and extended into the plastic range. This research may lead to applications of this concept for highly efficient impact energy absorption.

# Advanced Structures and Materials Applications

Research in this field showed that large, lightweight structures may be completely packaged for launching and expanded in space for use as reentry systems, solar power systems, and radio telescopes.

Work was initiated on high efficiency nonmetallic air locks for use in rendezvous between space vehicles or between space stations and supply vehicles. In preliminary tests such structures provided good environmental protection and excellent sealing against air losses, were adaptable, and could be stored in small spaces.

Studies of expandable structures for use as lunar shelters indicated likelihood of increased safety and reliability for manned lunar missions from such a portable life support shelter. This shelter, trans-

portable in the LEM vehicle, would permit stays on the moon up to 7 days, make it possible to move the operations center for exploration further from the landing point, and provide complete shelter at any time it is needed.

# High Temperature Structures

Ablation materials which can be easily applied and removed were developed and will be tested in flights of the X-15 research aircraft. Such materials will be required for reusable manned vehicles which must be repaired and refurbished as economically as possible after reentry heating.

Coatings applied by spraying and bonding will be evaluated for thermal protection effectiveness and for refurbishment costs and procedures.

#### Structural Dynamics

Ring baffles used to reduce the motion of liquid fuels and oxidizers are usually rigid and relatively heavy. Investigations at Langley and Lewis showed that flexible baffles can yield greater damping than rigid baffles for much less weight. There were indications of possible weight saving in later Saturn V vehicles which would permit an estimated additional 350 pounds of payload.

# Scout Reentry Heating Experiment

On August 18, a heat shield materials experiment was flown on a Scout rocket. All systems involved in the experiment operated well and excellent telemetry signals were received from the spacecraft after emergence from radio blackout. The objective of the experiment was to provide a reference point for ground based research and to test a candidate material for the Apollo heat shield. The data were employed as an anchor point for ground facilities used for ablation testing.

# FIRE I Reentry Heating Experiment

On April 14, the first experiment in Project FIRE was flown on the Atlas D rocket. Its primary objective: to investigate the heating environment of a blunt spacecraft reentering the atmosphere at lunar return speed (about 25,000 m.p.h.). All systems performed well; data were obtained on total heat transfer, total radiant energy of the gas cap, and its spectral distribution. Gross heating levels in this severe environment were defined, and the data will be used for interpretation of results from ground facilities and theoretical predictions.

# Spacecraft Electronics and Control

#### Communications and Tracking

Goddard Space Flight Center initiated experiments using lasers for satellite tracking when Explorer XXII was launched on October 10. Initial results indicated that the satellite was successfuly tracked by a station at Goddard in Greenbelt, Md. England and France and several U.S. industrial organizations also conducted laser tracking experiments using this satellit (fig. 4-3).

Langley Research Center continued research on loss of communications during spacecraft reentry. A flight test to study the effects of plasma sheaths returned useful diagnostic measurements (fig. 4-4).

In microelectronics, further research was conducted on radiation-resistant devices and a fast scan infrared detection and measuring instrument which could be used in reliability prediction, inspection, fabrication, and failure analysis of microelectronic devices. A microelectronics subcommittee of the NASA Parts Steering Committee was established to review and coordinate the NASA microelectronics program.

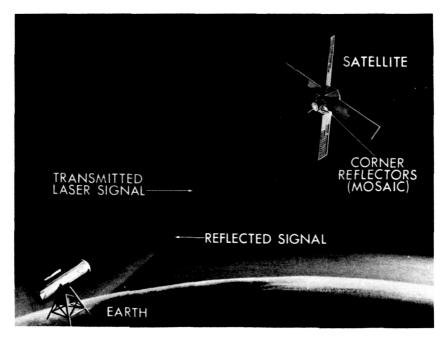


Figure 4-3. Laser tracking.

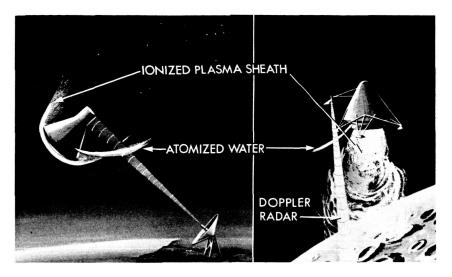


Figure 4-4. Reentry communications research.

#### Control and Stabilization of Narrow Optical Beams

A program to study and define the fundamental limitations, practical implementation problems, and research areas associated with the technology of narrow (0.01 to 1.0 arc-second) optical beams was started. Progress was made in systems analysis and synthesis, establishment of reference axes, development of techniques for measuring and positioning beams, and boresight maintenance. A factor and variable analysis of all components of such a system, including the space vehicle, the earth station, and the environment, was prepared. It indicated that present fine-beam steering techniques are adequate for a 1.0 arc-second beamwidth system, but that more sophisticated techniques must be developed for the 0.1 to 0.01 arc-second beamwidth systems.

This research on narrow optical beams is a necessary preliminary to the application of lasers to deep space communication and to the use of satellite-based optical devices for gathering information about distant galaxies, the earth, and solar physics.

# Guidance and Navigation

In research on celestial sighting devices, which will be the primary onboard navigation sensors for deep space flight, Ames Research Center investigated the possibility of using simple hand held or gimbal-mounted sextants for position determination as a backup to

more complex primary navigation devices or even as the primary sighting devices. Fixed-base and moving-base simulators and accurately positioned, simulated celestial bodies were tested by experienced aircraft navigators and astronauts.

Preliminary results showed essentially the same accuracy for gimbal-mounted and hand held sextants with measurement accuracies of about 20 arc-seconds. Oscillatory motions of the simulated spacecraft had little effect on sighting accuracy, but sighting through the visor of a pressure-suit helmet increased difficulty and reduced accuracy. Plans were made for similar experiments in the Gemini spacecraft flight to correlate simulator and space measurements.

#### Instrumentation

Further progress was made in developing methods of measuring gas parameters in atmospheric and space simulators (hypersonic tunnels, shock tubes, and other low density, high velocity test facilities) and for conducting research in hypersonic phenomena.

Langley Research Center developed probeless techniques for measuring free stream temperatures ( $-200^{\circ}$  F. to  $2,000^{\circ}$  F.), free stream velocity (5,000 to 6,000 f.p.s. at temperatures of  $1,500^{\circ}$  to  $3,500^{\circ}$  F.), and gas density. A laser beam was also investigated for use in measuring higher gas pressures up to one atmosphere. In conjunction with other methods, it would provide a capability for measuring gas densities over the total operating range of pressures.

At Marshall Space Flight Center, work on an image converter to replace conventional electron beam scanning TV tubes (*Eleventh Semiannual Report*, p. 99) progressed with the production of 50x50 element photo transistor mosaics having good uniform optical-electrical response of matrix elements. Peripheral equipment was being built to increase readout speed to match the larger number of elements. The objective of this research is to achieve the resolution attainable with conventional TV tubes in a device which is considerably more rugged and reliable.

An instrument originally designed by Ames Research Center for use as a micrometeoroid detector was improved to provide more effective noise isolation and was applied in biomedical research. It measured the heart beat of avian embryos, detecting the heart rhythm in chicken eggs 4 days after incubation.

#### Previous Element Coding

Research was underway to develop methods for processing the data gathered aboard future spacecraft so that fewer bits of information must be transmitted to earth for reconstruction of the scene viewed by the spacecraft cameras. In one technique, "Previous Element Coding" (figs. 4-5(a) and 4-5(b)) a scene viewed by a spacecraft camera is divided into a mosaic of many separate picture elements and each is assigned a binary coded number representing the intensity of shading based on a predetermined number of tonal increments to be represented in the total picture. Each element is examined in sequence, and if its shading is the same as that of the preceding element. only a single coding bit is transmitted instead of the entire coded num-This single bit tells the ground data processing equipment that the element it represents is the same shade of gray as the preceding element, and the computer then inserts the correct number into the reconstructed picture matrix. An improvement of about 2/1 should be possible using the "Previous Element Coding" scheme, thereby doubling the amount of information that can be transmitted over a particular communications channel, or halving the time required to transmit the same amount.

The initial phase of an investigation of thin film, laminated ferrite material for construction of high speed, large capacity, low power, miniaturized computer memories was completed. The ferrite memory (sheets of electrical conductors overlaid with a thin film of magnetic iron ceramic) should make it possible to store as many as 100,000 bits of information in 1 cubic inch in comparison with 2,000 bits per cubic inch for the ferrite core commonly used in present systems. (Fig. 4-6.)

In "hybrid" computer technology research a protype model of an advanced computer using digital techniques for control of analog computer functions was completed. It can make 1,000 computations per second of the type associated with trajectories, orbits, and impact points of space vehicles, a 10-fold increase over previous machines; it is also much more accurate and reliable.

Marshall Space Flight Center continued work on computer logic and control systems capable of operating in extreme environmental conditions of heat and radiation. Fluid systems, in which the operating medium is a liquid or gas instead of electricity, were found to be capable of reliable operation in environments normally damaging to equivalent electronic systems, and fluid components and circuitry for a number of computing logic operations were developed.

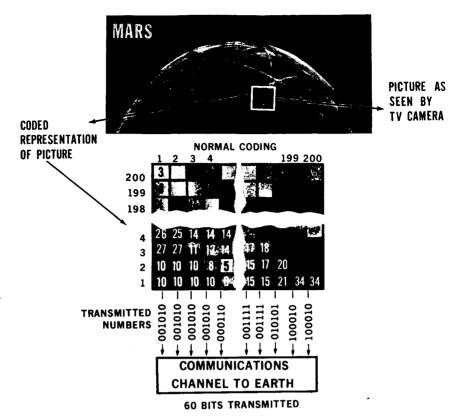


Figure 4-5(a). Previous Element Coding Technique.

# Aeronautics Research

## Aircraft Aerodynamics

Subsonic Aircraft.—As sonic velocity is approached, the speeds of subsonic jet transports are limited by formation of shock waves and by boundary layer separation on the upper surfaces of the wings. In wind tunnel tests of a relatively thick slotted-flap wing section, it was found that the normal shock wave can be drawn rearward and flow separation can be minimized by contouring of the section and the slot. In one case, the critical speed was increased from Mach 0.67 to 0.80.

Supersonic Aircraft.—An investigation was carried out at transonic speeds to determine the aerodynamic characteristics of canard airplane configurations with variations in wing and control surface planform (shape viewed from above). In general, trapezoidal wings gave better performance than delta wings, and trapezoidal canards

**DECIMAL SHADING LEVEL** 

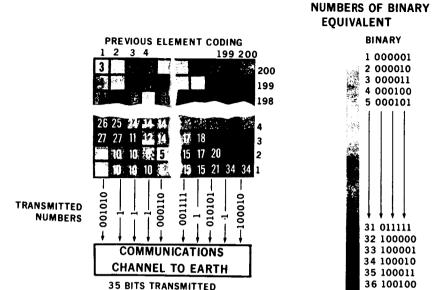


Figure 4-5(b). Previous Element Coding Technique.

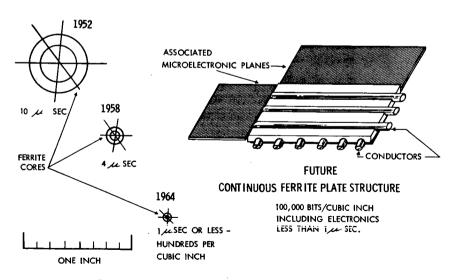


Figure 4-6. Progress in computer memory technology.

showed higher control effectiveness than delta canards at low deflections. However, trapezoidal canards stalled earlier and lost effectiveness at lower Mach numbers.

Wing-tip ailerons with skewed hinge lines were investigated. Proposed as a means of providing variable sweep wings with lateral control over a wide range of sweep angles, the ailerons were tested at Mach 2 in order to secure basic data on the effects of hinge-line location, control- to wing-area ratio, and deflection. The research indicated that simple geometric parameters (control area and control area moment) can be used in correlation studies of control effectiveness over a wide range of wing planforms.

Supersonic Transport.—NASA continued investigations of supersonic transport wing planforms. A low-aspect-ratio (relatively short wing span and long chord) clipped-delta-wing-body combination was studied to determine how much aspect ratio could be increased without losing the desired stability characteristics. It was found that removing area from the wing trailing edge reduced longitudinal stability, and removal of area from the leading edge increased the stability, but that removal from both materially increased aspect ratio with only small loss in stability at moderate lift coefficients.

In a study of a large scale delta-wing supersonic transport model incorporating midchord flaps in addition to leading-edge and trailing-edge flaps, significant lift increments for takeoff and landing were obtained with negligible pitching moment changes. The increment at large deflections could be approximately doubled by the use of boundary-layer blowing on the flaps.

Hypersonic Aircraft.—In research on near-earth-orbital rendezvous, a vehicle powered by an air-breathing engine showed significant superiority to the ballistic launch type vehicle. However, aerodynamic heating remained a serious problem since the most efficient cruise velocities were accompanied by the most severe heating conditions.

#### Aircraft Structures

Structural problems associated with the aerodynamic heating of supersonic and hypersonic flight continued to received research attention. Additional data was obtained on the mechanical properties of heat resistant materials exposed to long duration heating, with emphasis on such aspects of fatigue behavior as fatigue crack propagation rates and strength remaining in cracked speciments. Fatigue tests of titanium alloy box beams, representative of the wing structure of a supersonic aircraft, were carried on under contract. Also, in research on structural concepts for hypersonic air-breathing vehicles,

two fuselage specimens were being constructed for test and evaluation. And further research was conducted on the problem of dynamic instability or flutter of thin skin panels under supersonic flow conditions. Particular emphasis was placed on determining the effects of compressive stresses produced by heating, of Mach number and dynamic pressure, and of panel geometry and structural characteristics.

#### Large let Research Aircraft

NASA acquired a large jet aircraft (Convair 990 prototype) to support certain space science and aeronautical research programs. The space sciences programs will consist primarily of airborne astrophysical observations and geophysical measurements and observations related to planetary exploration. The aeronautical programs will investigate large aircraft handling characteristics as they relate to current airline and military operating problems; the results will provide basic information for future SST designs. The aircraft will also be used for research on propulsive and direct lift, advanced engines, on high-lift devices such as jet flap systems, and for flight research an avionics and variable stability. The first mission was planned for the aircraft; it will be to provide an airborne base during the May 1965, solar eclipse for what it is hoped will be the longest continuous period of observation of eclipse totality.

#### Passenger Restraint

NASA research in airline passenger restraint systems (an outgrowth of similar work in the astronaut protection field) yielded valuable data on the feasibility of using inflated structures for attenuation of crash impact on passengers. Swing impact tests were conducted and generally validated by two test crashes, in which the test aircraft carried models of the seat/protective bag system. Impact attenuations on the order of 1:10 were found feasible—in other words, in an airframe deceleration of 70–80 g's, the passenger would be subjected to a survivable level of only 7 or 8 g's.

# Hypersonic Ramjet Experiment

In the program on advanced ramjet propulsion systems operating between Mach 3 and 8, a request for proposal was issued, and industry submissions were received for evaluation.

## Vertical and Short Take-off and Landing (V/STOL) Aircraft

Research on high-performance rotary-wing aircraft with an all-weather capability analysed the effects of blade stall on rotor operation. Wind-tunnel tests were conducted at the Langley Research Center

with a 15-foot-diameter rotor operating under conditions expected to produce large areas of blade stall. The purpose of the tests was to provide a basis for further experimental and analytical study of the effects of blade stall and/or high tip-speed ratios on rotor aerodynamics and blade motions.

Rotor forces, power, and flapping and feathering motions were measured for several thrust coefficients at varying tip-speed ratios and several tip-path-plane angles of attack. Tests were also made to determine static stability derivatives with respect to velocity and the effects of large shaft-angle changes on rotor aerodynamics. The study showed that theoretical calculations and measured test results were in substantial agreement for certain conditions but differed for others. This work will be continued to develop usable analytical procedures for predicting rotor blade stall.

Investigations of the aerodynamic characteristics of propeller-driven tilt-wing aircraft continued with wind-tunnel and flight tests. Wind-tunnel tests of the first large scale, four-propeller, tilt-wing model indicated that air-flow separation on tilt-wing aircraft would limit descent performance and cause buffeting in the low-speed transitional flight regime. In flight tests of the VZ-2 tilt-wing airplane, it was found that the most critical region of operation was during decelerating conversion and/or descent where air-flow separation and wing stall produced buffeting, erratic motions, and general deficiencies in handling qualities. In wind-tunnel tests, premature air-flow separation occurred from the tilted wing center section outside the propeller slipstream and from an outboard area of the wing between the nacelles which was only partially immersed in the propeller slipstream.

Wind-tunnel tests of a model showed that air-flow separation over the titled wing center section limited maximum lift and produced horizontal-tail buffet. In the tests, it was also found that low-speed descent angles were less than 5° for the various flap, slat, and ramp configurations tested, but that descent angles greater than 10° could be attained by operating the inboard propellers at a higher thrust level than the outboard propellers.

In a related investigation, the stability and control characteristics of a 1/9-scale model closely resembling the triservice XC-142A airplane (fig. 4-7) were studied in free-flight tests which included hovering flights in and out of ground effect, level flight, and descent conditions in the transition speed range. No artificial stabilization was used in any of the tests. The model was statically and dynamically unstable for many of the flight-test conditions, but it could generally be controlled and maneuvered easily. It had at least a 6° descent capability with no adverse effects, and an additional 3° or 4°

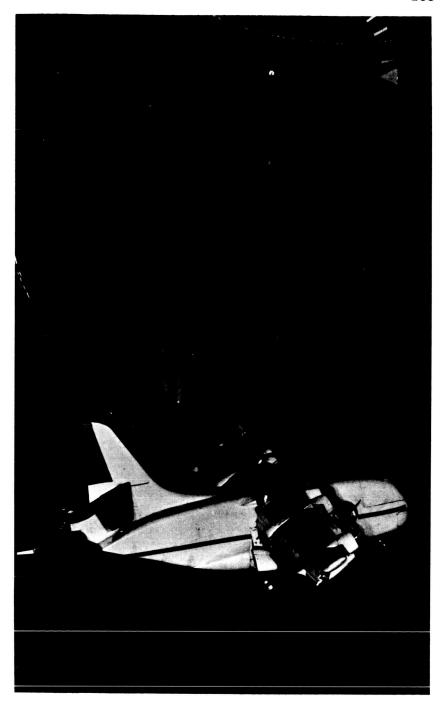


Figure 4-7. Transition flight of XC-142A model in Langley tunnel.

of descent angle was available before completely unacceptable flying qualities were encountered as a result of wing stalling. In all types of flight, the minimum total control powers found to be satisfactory in the tests of the model were less than the control powers which were planned for the full-scale aircraft. (Fig. 4–8.)

Jet-supported VTOL aircraft with high subsonic or supersonic cruise performance and capable of operating in areas where conventional landing facilities are not available were the subject of further studies. Additional information was sought on the interference effects of lifting jets, free-stream velocity, and model surfaces on the longitudinal aerodynamic characteristics of a VTOL model equipped with various interchangeable arrangements of single and of multiple round or slotted jets, with and without jet deflection. For all arrangements tested there were interference losses that generally increased with velocity ratio (ratio of free-stream velocity to jet velocity), and for most arrangements, nose-up pitching moments that increased with velocity ratio. For the model operating in ground effect, all arrangements showed a loss in lift at some distance closer to the ground than about seven effective jet diameters. Single-jet arrangements with central longitudinal slots and a multiple-jet arrangement with a fourjet diamond pattern out of ground effect and while hovering in ground effect produced less interference than other arrangements.

The full potential of V/STOL aircraft is limited by problems encountered in operation at low forward speeds. One significant problem area in the very low-speed flight regime—directional stability—was the subject of a flight investigation using a variable stability helicopter. The purpose of the study was to determine the effects of gross changes in static directional stability on V/STOL handling qualities. The tests indicated that increases in static directional stability accompanied by appropriate increases in directional damping yield improved handling qualities.

# Biotechnology and Human Research

## Biotechnology Flight Program

Studies of the effects of stress on physiological responses were being carried on by the Flight Research Center in cooperation with the USAF Aerospace Test Pilot School. This work seeks to determine the nature of physiological variables under a set of constant stressful conditions such as test pilot students encounter when they fly vigorous, consistent training missions. Data collected will provide a statistical baseline on the physiological responses of individuals of astronaut-standard while they are under stress.



Figure 4-8. Flight tests of XC-142A triservice transport.

Research was initiated on orbital biotechlogy piggyback payloads. Work was underway to demonstrate the feasibility of the flight configuration of the experiment as a preliminary to studies of flight hardware and payload space. Planned experiments include one using two squirrel monkeys in a closed environment in orbit for about 6 months to investigate physiological adaption to prolonged space exposure, and another orbiting an electrolyte cell to find out whether it can electrolyze water into hydrogen and oxygen in a gravity free environment.

#### Life Support and Protective Systems

Life Support Systems.—A prototype of a partially regenerative multiple-manned system for operation up to 1 year with resupply every 90 days was being built by a contractor under supervision of the Langley Research Center. In this system, which can recover oxygen and water from both gaseous and liquid waste, weights have been reduced to 16 lbs. per man per day by utilizing waste thermal energy for the regeneration process. It will be studied by the Langley Research Center during the next year.

Protective Systems.—Various types of equipment to guard man against vibration, acceleration, and impact during all mission phases and to provide the capability for extravehicular operations were being developed. The Ames Research Center worked on a suit which combines both support and restraint in one unit. The Manned Spacecraft Center contracted for a hard metal suit fabricated with 0.030-inch aluminum which offers greater protection and lower resistance to arm and leg movement. The suit employs a constant volume concept allowing movement through rolling convolute joints. A study was completed on extravehicular locomotion, and preliminary design was initiated of locomotion devices attachable to the astronaut for maneuvering in free space and on the lunar surface.

Control Systems.—Development of controls which permit minimum supervision of equipment progressed with studies of a one man locomotion system controlled by voice inputs. In tests conducted during the report period, the controller consistently recognized specific words.

#### Human Research

Research on man's psychological and physiological reactions to the hostile space environment included studies of radiation, reduced gravity, and acceleration forces.

Radiobiology.—In this field, research at the University of California and the Ames Research Center produced the first meaningful information on the biological effects of the proton component in

radiation likely to be encountered in space flight. Animal experiments in the University of California cyclotron showed that at the lethal dose level the biological damage mechanism of proton radiation for small animals is similar to that of gamma radiation. Confirmation of these preliminary results with tests of other species would mean that the extensive knowledge of gamma radiation effects already available might be applied directly to the problems of radiation hazards in space flight.

Acceleration and Gravity Stress.—Ames Research Center continued work on a laboratory technique which may compensate for the inability to simulate directly the effects of long-term reduced gravity on physiological systems. In this method, each of several groups of test animals was subjected to a different level of acceleration in a centrifuge for a prolonged period and the resultant data on physiological differences among groups were analyzed for correlation with acceleration (or gravitational) level. If a significant relationship can be established between physiological phenomena and gravitational stress at acceleration levels greater than 1 g, it might be possible to predict by extrapolation effects at acceleration levels less than 1 g.

Preliminary results of a study of the effect of altered gravity environment on small animals indicate certain changes in growth, size, and body chemistry. Rats subjected to tests in a centrifuge for as long as 1 year at g loads ranging from 2.5 to 4.7 above normal gravity did not grow to normal size. Further tests were planned to verify these findings and to discover the biological mechanisms producing them.

# Man-Systems Integration

Tether Line Studies.—Astronauts operating outside their spacecraft will use space suits with propulsion devices for moving about. To insure their safety, it will be necessary to link astronauts to their spacecraft by a flexible tether line. However, the astronaut cannot return to his vehicle by merely reeling in the tether line. Studies indicated that recovery will be difficult because of the inherent angular rotation of the astronaut and the spacecraft caused by angular momentum.

For example, an astronaut outside his ship might move away and begin to circle his ship at 3 or 4 m.p.h. while tied to the end of a 200-foot line. He completes a circle around his ship in about 4 minutes and then asks to be hauled in. His safety line draws him closer and closer to the ship but cannot change the 3 or 4 m.p.h. circling speed. The line just reduces the size of the circle, and within 5 feet of the ship, the 3 or 4 m.p.h. speed would drive the astronaut around

this very short path at more than 300 revolutions a minute and would increase his weight to more than 200 times normal.

Langley Research Center investigated controlled tethering and found that the loads on the astronaut can be made negligible by deploying a few pounds on a long line from the astronaut to absorb the angular momentum. Work was started on the preliminary design of a retrieval system using this principle.

Maintainability.—Studies were being conducted on visual, tactile, locomotor, and decision making performance tasks related to maintenance problems in the space environment.

Reduced Gravity.—The effect of reduced gravity on human performance was under study at the Langley Research Center. Data from investigations in simulated lunar gravity (1/6 g.) established man's general capabilities (locomotion and increased capacity to carry loads) in reduced gravity. Precise data were being gathered on human performance and energy expenditures of men wearing space suits and other equipment and carrying on typical duties in space and on the lunar surface. Plans were made to include in this research tests of human performance under zero gravity conditions.

Performance Test Battery.—A console incorporating 20 different human tasks (such as motor skills, sensory acuity, decision making, and problem solving) was being developed by the Ames Research Center for use in an orbital space laboratory, and preliminary selection of the specific tests for an integrated performance test battery was completed. Some of the measurements in this battery were selected for their ability to aid in the evaluation of manual performance under stress conditions (fatigue) which could be encountered in a space system. Measurements, in this case, refer to specific behavioral tests which can be integrated into a single testing console and will provide quantitative assessment of human performance.

Manual Navigation and Control.—Techniques were developed which can be used for manual control of a spacecraft in a lunar landing or an abort of a lunar landing in case automatic systems fail, and studies were made at Langley of the effects of overloading the pilot during critical manual control stages.

## Chemical Propulsion Systems

## Solid Propulsion Technology

The entire solid propulsion research and technology program includes approximately 100 separate contract and in-house tasks. During this period, metal combustion, mechanical behavior of propellants, and hybrid propellant motors were among the subjects investigated.

Metal combustion is an important problem because it has a bearing on nozzle flow and, hence, on performance, design, and high frequency combustion instability. Metal combustion is itself a source of combustion instability, particularly in the frequency range below 500 c.p.s. Metal combustion problems, which are related to the microscopic processes of agglomeration and combustion of metal droplets and can be subjected to photographic study because of the high luminosity of metal combustion, were under study at Princeton University, Jet Propulsion Laboratory, and Naval Ordnance Test Station.

The mechanical behavior of solid propellants was the subject of an extensive program, principally at JPL. The applicability of continuous media theory to the solution of the stress analysis problem, new methods and improved instrumentation for measuring propellant physical properties, and failure mechanisms were investigated.

Hybrid propellants—a liquid oxidizer, a solid fuel grain, and a means of controlling the flow of oxidizer into the fuel grain section, which acts as the combustion chamber—offer the potential advantages of high performance and safety. However, before they can be applied in future space systems, they must be throttleable over a fairly wide range of thrust. During the period, the first contract was let to investigate combustion problems associated with throttling and the technique of throttling a hybrid engine. This work will lead to a prototype engine with a burning time of 120 seconds at full thrust and capable of being varied in thrust between 5,000 and 625 pounds.

# Large Solid Propellant Motor Program

The national large solid motor program, a joint effort of NASA and the Department of Defense, was to demonstrate the feasibility of very large solid propellant motors and to advance their technology. Contracts were let previously for static firings of 156- and 260-inch diameter solid motors, and in July 1964, NASA assumed funding responsibility for the 260-inch motor portion of the program. (Fig. 4-9.)

During the period of this report, two 156-inch-diameter solid motors were successfully tested. In September, a jet tab steering control system was evaluated for the second time on a 156-inch motor. A thrust level of 1,200,000 pounds for a duration of 2 minutes was attained. In December, a contractor successfully static fired a 156-inch-diameter segmented solid motor which included a gimbal nozzle (one which can be moved in any direction to produce steering force). This motor generated 1,300,000 pounds of thrust for approximately 2 minutes. Some of the nozzle ablative components were lost late in this test, but all critical objectives were met.

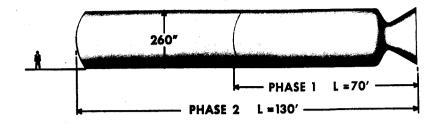


Figure 4-9. 260-inch motor sizes.

One 260-inch-motor contractor was in the final stages of preparation for static firing a 156-inch-diameter motor which will generate more than 3 million pounds of thrust and is a direct lead-in to their 260-inch motors. In September, the other 260-inch-motor contractor successfully static fired a 120-inch-diameter subscale motor. This motor, predecessor of the company's 260-inch motors, delivered over 600,000 pounds of thrust for about 80 seconds and proved that the propellant manufacturing technique to be used in their 260-inch motors would be satisfactory and that the ablative nozzle construction would be suitable for the larger sizes.

Subcontractors were manufacturing 260-inch-diameter motor cases and nozzles; at the end of the report period, the first cases were nearing completion and the second cases were being fabricated. Problems encountered in fabricating tooling to handle the very large cases and also in the preparation and welding of the high-nickel alloy maraging steel were solved and fabrication proceeded on a relatively routine basis.

The nozzles for the 260-inch motors were in the early stages of fabrication. The designs used by the two subcontractors are similar in that they consist of ablative plastic inner sections surrounded by a steel jacket.

## Liquid Propulsion

Launch Vehicle Propulsion.—In an earlier test of the M-1 injector and uncooled thrust chamber, a malfunction in the oxidizer valve on the engine caused a fire which damaged the test stand and equipment. As a result of an investigation of the malfunction, the engine valve was redesigned and all three component test stands were modified extensively. Scale model pumps and single-element injectors were tested, and the gas generator test program, resumed in November, made significant progress. Plans were made to begin using the turbopump

test stand with the full-scale oxidizer and fuel pump assemblies and the stand for thrust chamber testing.

In work on liquid rocket engine design concepts, the feasibility of two new concepts suitable for high-pressure operation was demonstrated and the detailed engineering data required for design analysis was being accumulated. Hot firing tests of critical components were underway, and related work on pumping and cooling continued.

Space Propulsion.—In this program, the RL-10 pump-fed, oxygenhydrogen upper-stage engine satisfactorily completed a series of tests operating with the fluorine-hydrogen propellant combination. The tests were part of a planned program to establish compatibility of the system with liquid fluorine. Engine components were identical with standard RL-10 parts, except oxidizer feed system components (a modified pump and associated valving) and newly developed dynamic seals for the oxidizer pump capable of operating for over 30 minutes. To improve engine performance, the propellant injection system was being modified for operation with fluorine-hydrogen, and additional work on fluorine-hydrogen engine operation in the lower operating pressure regime was planned. The purpose of this work will be to establish the operating characteristics of fluorine-hydrogen engines suitable for pressure-fed propulsion system applications.

Work on space storable propellants was increased as was related research on engine chambers for these propellants. Fuels were classified with respect to physical properties affecting space storability and thrust chamber cooling capabilities, and the most promising selected for experimental testing; the FLOX-light hydrocarbon fuel investigation was well underway.

Auxiliary Propulsion.—The auxiliary bipropellant engine program was in the design stage. Five injector types were rated for performance, transient stability, and heat transfer rate to combustion chamber and nozzle walls; several thrust chamber designs with 1-hour life were being analyzed; and the hydrazine catalyst work reached the stage where a number of projects were started by NASA, the Air Force, and the Navy to utilize this monopropellant system.

Research.—Combustion instability, a continuing problem in engine development projects, received increased attention as new approaches for obtaining a design tool and better techniques for coping with the problem in operational engines were reviewed. At the same time, in research on better instrumentation, an experimental model of an instrument which can diagnose operating engines and take corrective action to increase operating reliability was demonstrated.

#### Basic Research

#### Fluid Physics

In plasma physics, research has shown that the behavior of ionized matter in interplanetary space is dominated by collective effects resulting from the interactions of groups of particles. In laboratory experiments, the environment in which interplanetary plasmas exist was simulated, and the mechanism of energy dissipation through collective effects which do not involve single-particle collisions was studied. For the first time, collisionless damping of waves in a plasma was demonstrated. The work verified plasma theory concerning collective effects and constitutes an important advance in the understanding of particulate-radiation trapping in the geomagnetic field, of rocket exhaust characteristics at very high altitudes, and of the solar wind.

In entry vehicles research, an analytical technique was developed at the Ames Research Center to predict the shock wave shape and the location and other characteristics of the flow field about vehicles entering the atmosphere of the earth and of other planets. The technique was successfully applied over a wide range of conditions. In addition, other methods of solving the fundamental equations of motion were being studied at Ames and Langley and by contractors to fulfill the continuing need for more exact solutions to flow field problems.

## Applied Mathematics

Mathematicians at Jet Propulsion Labatory applied the Method of Averages to spaceflight mechanics. The Method can be used to solve nonlinear differential equations, such as those describing the motion of a satellite about an oblate planet, and has the advantages of relative simplicity, workability, and exactitude of the resulting solutions. In addition, the formulas are valid for all eccentricities and inclinations of satellite orbits, whereas older methods become invalid for extreme values of these elements. This method is especially applicable to the study of satellite lifetime because it requires a relatively short program on a digital computer, yet is accurate and economical because of the time it saves in programing such a frequently repeated computation.

#### Materials Research

Polymers.—In investigations of new materials to withstand the space environment, Marshall Space Flight Center discovered and was

developing a new polymer system. This new series of polymers, which enhances the properties of the commercially known silicones, has the outstanding property of stability for short periods at temperatures in the 900° to 1100° F. range. These polymers may have space applications as thermal control coatings, molding compounds, and adhesives and may also be useful commercially.

Metallic Technetium.—Technetium, one of the few elements which have never been found in the earth's crust, is of interest by itself and as an additive to other metals and alloys. As the closest relative of rhenium, the only alloying addition capable of curing the room-temperature brittleness of tungsten and chromium, technetium can be expected to have a similar metallurgical behavior.

Under a NASA contract, the Hanford Laboratories, of the AEC's Hanford Atomic Products Operation, using an ion-exchange technique and atomic reactor waste products as raw materials, produced about 2 pounds of technetium (several times the previous total world supply). This process could produce a number of tons per year, at a cost of \$1 or less per gram.

Research was also conducted on various tungsten-technetium alloys to determine their strength and ductility and to increase understanding of the "rhenium effect." This work is also expected to expand knowledge of flow and fracture mechanisms in these refractory alloys and thus to permit the production of ductile alloys for improved rocket nozzles, high temperature jet engine blading, fuel element cladding, superconductors, and thermionic emittors.

Stress-Corrosion of Titanium.—The Langley Research Center studied the various leading alloys of titanium to determine the influence of such variables as stress, temperature, air pressure, moisture content, surface condition, and oxygen content of the air. In one phase of NASA's research program on the susceptibility of the alloys to stress-corrosion cracking, the data indicated that advanced engines and airframes will be operating under critical conditions for stress-corrosion cracking. Other parts of the program studied the physical-and chemical phenomena involved and worked to develop coatings to protect the titanium from the corrosive environment.

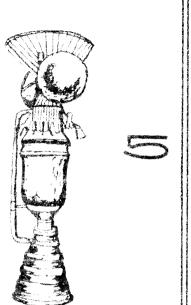
The data sought in this program will be applicable almost immediately to research on compressor blades of advanced gas turbines and the airframes of supersonic transports.

# **Electrophysics**

In research sponsored by NASA, an investigator produced pulsed coherent acoustic energy at frequencies up to 60 billion cycles per second at appreciable power. An exceptionally high intensity pulsed

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laser beam was used to irradiate solids (quartz, sapphire) or liquids (water, carbon tetrachloride, acetone, methane). The interaction of the laser beam with the material produced the acoustic wave energy. This research makes available a new technique for probing the structure of matter. It should make it possible to investigate the finer details of acoustic-magnetic-electric energy transformations and should lead to improved performance of electronic devices such as semiconductors and microwave components. The acoustic waves might also have applications in industrial nondestructive testing.



NUCLEAR
PROPULSION
AND
POWER
GENERATION

NASA's nuclear propulsion and power generation efforts include the nuclear rocket technology program, the SNAP-8 electric power generation system development project, nuclear electric power research and technology activities, and the electric propulsion (electric rocket engine) program. The Agency made noteworthy progress in each area during the period.

## The Nuclear Rocket Technology Program

The Nuclear Rocket Technology Program is a joint endeavor of the National Aeronautics and Space Administration and the Atomic Energy Commission. This program, as was pointed out in NASA's earlier seminannual reports, is concerned with developing the technology for using nuclear propulsion for space missions. Two projects of the program, KIWI and NERVA, are aimed at developing components and subsystems for a 1,000-megawatt, 50,000 pound-thrust, experimental ground-based nuclear rocket engine. Additionally, a Supporting Research and Technology effort is concerned with advanced reactor research, the evaluation of alternate concepts, mission applications and requirements, vehicle technology development, and flight safety.

#### **KIWI**

Two significant reactor experiments were conducted by the Los Alamos Scientific Laboratory (LASL) during the latter half of 1964. Both involved the use of the LASL KIWI-B4E reactor, the eighth and final reactor to be fabricated and tested under the KIWI phase of the ROVER program.

The first of these experiments was conducted on August 28, 1964, to obtain further operating data concerning fuel-element capability and the structural design of the reactor under long-duration, high-power operating conditions. The reactor was run at planned power and temperature for approximately 8 minutes, the maximum time possible with the available liquid-hydrogen supply. During startup, operation at the planned power plateau, and shutdown, reactor performance was smooth and "uneventful." There was no evidence of the vibrations encountered in the KIWI-B4A power test on November 11, 1962. All test objectives were met. The test also confirmed the results of the KIWI-B4D experiment; that the current KIWI-B4 design was sound. The nozzle performed satisfactorily.

The second B4E reactor experiment was carried out on September 10, 1964. (See fig. 5-1.) The decision to conduct this test was based upon the preliminary analyses of the test data from the August 28 run which indicated the reactor was in excellent condition and could be rerun. The reactor was restarted and run at near full power for approximately 2.5 minutes. Reactor shutdown was accomplished as planned. The capability to rerun reactors, as demonstrated by this experiment, came much earlier than anticipated, and was deemed a significant step towards the economical development of nuclear rockets.

As planned, the KIWI project was concluded with the KIWI-B4E experiments. The Los Alamos Scientific Laboratory now is concentrating on the development of higher power graphite reactor technology (PHOEBUS graphite technology program).

# **NERVA** Project

The successful KIWI-B4E power tests were accompanied by two significant NERVA (Nuclear Energy for Rocket Vehicle Application) reactor experiments. These experiments involved the use of the NRX-A2, the first power reactor fabricated under the NERVA experimental engine program.

In the first NRX-A2 test, conducted on September 24, the reactor was operated for approximately 6 minutes at powers ranging from approximately one-half to near full power. While the duration of the run was limited by the available supply of hydrogen gas needed for

turbine drive and reactor cooldown (depleted during a lengthy weather hold), the test was successfully completed.

The second NRX-A2 experiment (October 15, 1964), involving restarting the reactor, was conducted to explore the behavior of the NRX-A2 system in the low-power, low-flow region. All test objectives were met and the reactor operated stably and reliably. The disassembly and post mortem examination of the NRX-A2 were completed and results were being analyzed and evaluated to determine what changes should be incorporated in subsequent NRX-A designs.

In addition to NERVA reactor development under the experimental engine program, continuing efforts were devoted to developing the

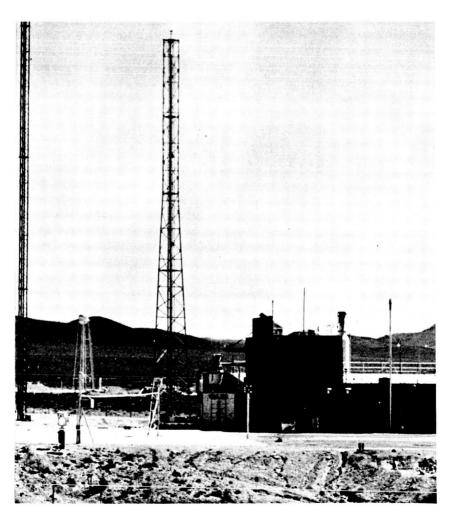


Figure 5-1. The KIWI-B4E power test.

nonnuclear components essential for ground engine system testing. These components include the engine nozzle, turbopump, turbine power control valve, tank shutoff valve, engine piping and control system.

A significant amount of effort was also being devoted to nozzle development. One nozzle, shown in figure 5-2, was used at near design heat flux conditions during the NRX-A2 power experiments; additional work is needed to assure sufficient performance margins for all reactor and engine requirements. The hydrogen feed system, including the turbopump and turbine power-control valve, was also under development. The design of the turbopump was completed and fabrication was in progress.

Efforts to develop reliable hydrogen-cooled bearings continued, with accumulative test durations of approximately 140 minutes, in a non-radiation environment, being achieved. These bearings must be able to operate satisfactorily in a radiation environment over a wide range of load conditions.

Work on the NERVA engine system, while mainly analytical and design, was leading to cold flow and power tests of engine systems beginning in 1965. Cold flow experiments include the Cold Flow Development Test System tests (CFDTS), scheduled to begin in early 1965. At the conclusion of these system experiments at Sacramento, the cold flow engine hardware is to be moved to NRDS for activation tests of Engine Test Stand-1 (ETS-1). First engine system power tests will be conducted using the modified NRX test assembly.

## Advanced Research and Technology

In support of the nuclear rocket program, advanced research and technology efforts were actively continuing. These efforts are chiefly directed toward advanced reactor research, nonreactor component and engine system technology development, and vehicle technology development.

Advanced Reactor Research.—Reactor development under the NERVA project, based on the graphite technology developed under the KIWI project, is complemented by the Los Alamos PHOEBUS advanced graphite technology program. This program is aimed at providing higher power levels and the technology for improving specific impulse and duration.

The initial work in PHOEBUS began approximately 16 months ago with experimental measurements of neutron physics parameters in honeycomb critical assemblies. These early experiments provided the data required to begin the preliminary design of a 5,000-megawatt large reactor. The current effort is aimed at designing, fabricating,

developing, and testing high-powered PHOEBUS 2 reactors. Included in this work are: (1) more sophisticated zero power experiments to refine neutronics data, (2) component development, and (3) research leading to improved performance. Tests of KIWI-sized reactors (PHOEBUS 1 reactors) also are planned to provide design data and technological information toward the development of PHOEBUS 2 reactors.

In addition to the PHOEBUS development work LASL performed some clustering experiments with KIWI-sized reactors. These ex-

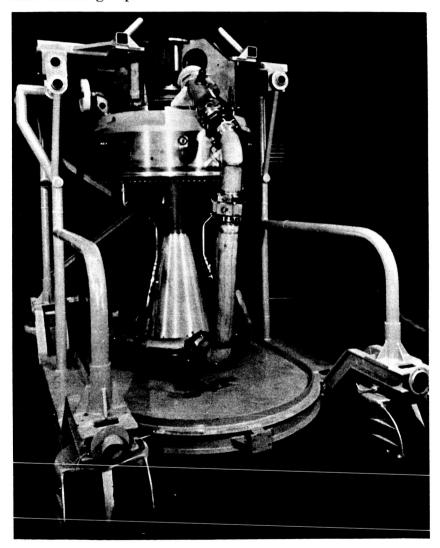


Figure 5-2. A nozzle for the NRX-A2 experiment.

periments showed that the nuclear interaction of reactors at criticality is negligible, and that fully independent operation of clustered engines seems entirely feasible. Such clustering greatly enhances the ability of nuclear propulsion systems to meet a variety of space mission objectives.

Commensurate with the development of large-graphite reactor technology, NASA and the AEC also were exploring the feasibility of using tungsten as a reactor fuel-element material. The Lewis Research Center, in support of this endeavor, was investigating a thermal, water-moderated, tungsten reactor concept. Also, the Argonne National Laboratory was investigating a tungsten fast-reactor concept. The emphasis at both activities was on fuel-element and materials research, since it is in these areas that feasibility and performance are likely to be established.

Nonreactor Component and Engine System Technology Development.—Work was initiated to develop the technology of major nonreactor components for a PHOEBUS-reactor type engine. Certain of these components, such as feed systems and nozzles, are required for reactor tests.

The nozzle development problems for PHOEBUS reactors are in many ways similar to the problems encountered in the development of KIWI-NERVA nozzles. Therefore, much of what was learned from KIWI and NERVA is serving as a base for the newer work.

In the feed system area, NASA was considering several ways of meeting the requirement for increased hydrogen flow for PHOEBUS reactor testing. If the performance of the present pumping system (the NFS-2 being used in KIWI-NERVA reactor testing) can be increased, then the requirements can be met by coupling two or more of these pumps in parallel. Ways of modifying this pump were being studied. Also, the Agency was giving some consideration to meeting facility requirements by modifying a pump under development for the M-1 hydrogen-oxygen chemical engine.

Vehicle Technology Development.—In the vehicle technology area, a series of fundamentally important tests were completed. Measurements were made of the slowing-down effect of liquid hydrogen on neutrons, simulating a condition expected to exist during operation of a nuclear rocket-powered vehicle. Test results should help predict the effects of neutron heating of hydrogen. They should also help predict the undesirable effects brought about by hydrogen boiling and pressure rise.

In still other study areas, techniques were developed to predict strength of thin walls for propellant tanks; a foam type insulation suitable for internal or external application was developed; and improved methods of welding aluminum were perfected.

#### Safety

The major subject of research under the safety program concerns the assurance of safe use and handling of nuclear rocket reactors and the hydrogen propellant. Operational plans, programs, and procedures for the safe transportation, assembly, testing, and disassembly of reactors at NRDS already have been established. Also, a neutron poison wire concept was investigated for precluding nuclear accidents during ground handling and launch.

A problem introduced by nuclear propulsion concerns the safe disposal of the reactor after its use in space. When the reactor is started prior to reaching orbit, a high explosive reactor distruct system which pulverizes and disperses the core would be employed. If the reactor is not started until an earth orbit is achieved, preliminary analyses strongly indicate that a completely safe system is possible without any countermeasures. Additional analyses and experimental work are to be performed during the coming year to confirm these details and to make sure that safety is a fact under all conceivable circumstances.

#### **Facilities**

The construction of facilities at the Nuclear Rocket Development Station (Nevada Test Site) was continued through this report period. Construction completed included hot cells for the postmortem examination of reactors in the reactor maintenance, assembly, and disassembly building; an administration and engineering building; and the engine maintenance, assembly, and disassembly building.

# The SNAP-8 Development Project

The objective of the joint NASA-AEC SNAP-8 project has been to develop a 10,000-hr., 35-kw.-e. nuclear electrical generating system suitable for use in advanced space missions.

During this reporting period, all major power conversion system components were being tested and the first SNAP-8 power conversion system was nearly constructed. (Fig. 5-3.) Preparations for the first SNAP-8 integrated system test were underway.

The turbine-alternator, electrical controls, condenser, mercury pump, and lube/coolant pump performed satisfactory under actual or simulated system operating conditions. The sodium-potassium (NaK) pumps also performed satisfactorily in water loops in preparation for testing at system conditions. By the end of the period, the SNAP-8 Experimental Reactor had been operated by the AEC for over 7,800 hours, 5,800 of which were conditions required for a system output of 35 kw.-e.

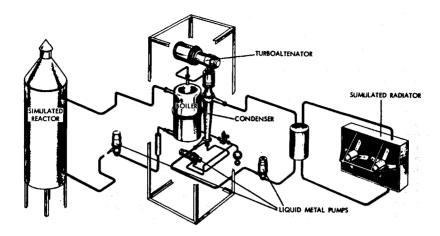


Figure 5-3. The SNAP-8 power conversion system test arrangement.

The boiler demonstrated satisfactory performance after run-in. However, it did not develop superheat reliably at startup, and corrective action was in progress.

## Nuclear Electric Power Research and Technology

Continuing efforts were being directed toward finding means of converting nuclear thermal energy into electric energy for spacecraft, lunar or planetary base auxiliary power, and for propulsion engines. Concepts being considered were the Rankine cycle turbogenerator, using the so-called liquid metals as working fluids; thermionic direct conversion; the Brayton cycle gas turbine; and the liquid metal magnetohydrodynamic generator.

Basic measurements of the thermodynamic and transport properties of liquid and vapor potassium were completed in support of advanced Rankine cycle technology. Additional data on the strength and corrosion properties of refractory alloys, potassium boiling and condensing heat transfer, cavitation in liquid metal pumps, and liquid metal-lubricated bearing parameters were also obtained.

Testing began on the first large size potassium vapor turbine ever constructed. After approximately 40 hours of operation, the turbine showed evidence of sustaining considerable liquid droplet erosion damage. The damage mechanism is now under investigation.

Particle impact testing, to provide data for design of cycle waste heat radiators, uncovered a serious cracking problem with materials such as beryllium, graphite, and molybdenum, heretofore considered most desirable for construction of lightweight radiators. Data obtained during the period also indicated that the correlations which describe crater damage to metals do not seem to apply to nonmetals such as graphite in which different damage mechanisms appear to be involved. Thus, the crater depths in graphite were found to be only about one-half the predicted value.

In thermionic conversion research, the primary effort continued to be directed toward seeking solutions to the materials problems associated with the high temperatures required for efficient operation. Additional data on the high temperature compatibility of emitter materials with uranium bearing fuels was obtained. Fundamental data were obtained on the vaporization rates of nuclear fuels at high temperatures and on the electrical resistivity of insulator materials under reactor irradiation. Life tests of up to 5,000 hours have been run on single cell electrically heated thermionic converters.

The radial units tested to date have delivered the efficiency values that were predicted. As expected, difficulties were encountered with the high-temperature gas bearings. These bearings were to be used in the combined compressor-turbine packages that were to be built and tested following separate testing of the turbine and compressor components. An extensive research program has been established to investigate the gas bearing problems.

The Brayton gas turbine power system, shown schematically in figure 5-4, is of interest for both nuclear and solar heat sources. A joint program, conducted under the NASA Solar and Nuclear Power Programs, is aimed at building a Brayton turbomachinery technology base. Typical of the component information of interest to both programs are the small size compressor and turbine evaluations that were being conducted. These components are useful for both solar and isotope low power Brayton systems. Both radial and axial flow units are being built under contract and are to be tested by NASA.

In another area of effort, NASA was investigating the possibility of generating electric power in space directly from a moving, electrically conducting working fluid. The device that could accomplish this is called the magnetohydrodynamic (MHD) converter; it would be used in place of the turbogenerator in a conventional Brayton or Rankine cycle. The Agency is considering this device because it does not have moving parts as does a turbine and therefore would be less adversely affected by high temperature and appears attractive for long-endurance operations.

An MHD powerplant concept was being investigated at the Jet Propulsion Laboratory. The concept is based on passing a high-velocity liquid metal (the conducting fluid) through the MHD generator. NASA is interested in this concept because the comparatively low temperatures it requires are much nearer to attainable reactor

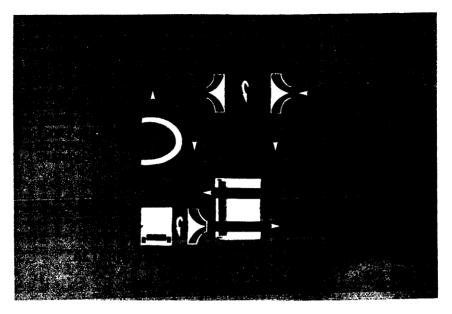


Figure 5-4. Schematic of Brayton gas turbine power system.

technology than those required by conventional all-gas MHD systems. Tests were performed on the four main components of the JPL liquid MHD system: nozzles, vapor-liquid separators, diffusers, and an MHD generator. (The MHD generator produced 12.8 kilowatts of power at 52 percent of theoretical efficiency and verified the validity of the concept.)

# The Electric Propulsion Program

The electric propulsion (electric rocket engine) program provides the research data and advanced technology for development of electric thrustor systems. This program is composed of two elements: electric propulsion system analysis and experimental evaluation, and research and technology efforts on the three main types of electric thrustors.

# System Analysis and Experimental Evaluation

As part of this element, the current phase of the SERT (Space Electric Rocket Test) project is directed toward evaluating competing thrustor systems for satellite control. At the Lewis Research Center an air-bearing table mounted in a vacuum tank will be used to permit selection of the more promising system for further development and possible flight evaluation. In addition, the Goddard Space Flight

Center uses an electric propulsion station-keeping and attitude-control simulator to investigate the various electric systems. This simulator helps to determine optimum system operational modes and to define subsystem interaction problems.

Further, as part of the overall phase of this effort, NASA (through JPL) initiated a study of electric propulsion systems utilizing light-weight solar cell arrays as the power source for unmanned planetary missions.

#### Thrustor Research and Technology

In this second element of the program, continuing investigations of three types of thrustors (electrostatic, electrothermal, and plasma) were carried out.

The electrostatic or ion thrustors received major emphasis because of their demonstrated high efficiency. Preliminary investigations on the surface contact and the electron-bombardment ion thrustors were previously completed, and the bulk of the program has been oriented toward their further development. A third type, the colloidal thrustor (which accelerates charged heavy particles or molecules instead of ions) remains in the conceptual research stage. However, it offers the potential of higher thrust per unit area and a wider propellant selection.

One of the early unresolved problems concerned neutralizing an ion beam in space. To verify research results, NASA conducted a suborbital flight test (SERT I) on July 20. The test was successful. (See fig. 5-5.)

During the flight, a small 1½-kilowatt Lewis Research Center mercury electron-bombardment thrustor, producing about 6 thousandths of a pound of thrust, was operated successfully for a total of about 30 minutes. This accomplishment was considered a major milestone in the thrustor program from a research standpoint and was this country's first successful test of an electric thrustor in space.

A ½-kilowatt cesium contact thrustor also aboard the SERT I spacecraft failed to operate during flight because of a high-voltage breakdown. This failure did not influence the validity of the flight results, but did emphasize the need for continued research in high-voltage power conditioning.

The SERT I flight proved conclusively that the positively charged beam of ions from an ion thrustor can be neutralized in space. Flight test data laso correlated well with ground vacuum facility results, thus also confirming the validity of established ground laboratory practice. The success of this first electric rocket engine flight obviated the need for a repeat of SERT I-type flight tests.

The current major research effort on the contact ion thrustor has

been proceeding in the 3-kilowatt range to evaluate operating life, performance capability, and major problem areas. Research during this period concentrated heavily on the ionizer, with a 3-kilowatt linear strip contact thrustor undergoing tests at the contractor's plant. This engine uses the latest developed ionizer material which appears to have good characteristics for long life. The goal is to achieve over 1,000 hours of reliable operation.

The principal research effort on the electron-bombardment ion thrustor, also in the 3-kilowatt range, was devoted to improvement of the cathode life. The cathode in this type of thrustor charges the propellant by bombarding it with electrons. A 3-kilowatt mercury electron-bombardment research thrustor, employing a filament-type cathode, was being evaluated at Lewis Research Center. During this period, cathodes for this thrustor were operated for over 4,000 hours under simulated thrustor conditions. These results could be considered to give approximately a 2,000-hour thrustor life when incorporated in an actual thrustor.

A 3-kilowatt cesium-bombardment ion thrustor, employing a promising cathode design concept called the autocathode (discussed in the *Eleventh Semiannual Report*), was fabricated. (See fig. 5-6.) A successful endurance run of 880 hours was completed in February. Inspection indicated negligible erosion and the engine will be reassembled for further testing.

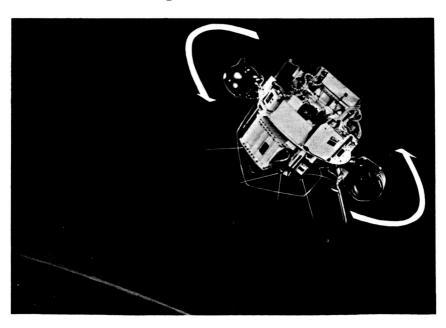


Figure 5-5. The SERT I spacecraft.

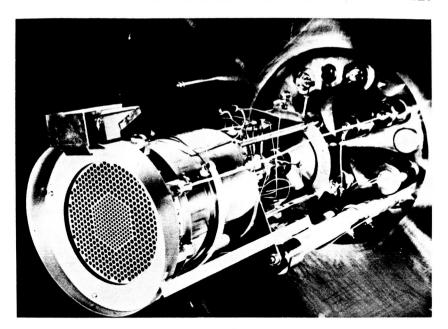


Figure 5-6. A 3-kilowatt cesium-bombardment ion thrustor.

Both clustering and scaling of the Lewis 3-kilowatt electron-bombardment thrustor up to the 30-kilowatt level were demonstrated with no major difficulties. Further scaling of the mercury electron-bombardment thrustor to the 100-kilowatt range is planned.

The research program on electrothermal thrustors involves two types of engines, the resistojet and the thermal arc jet. In the resistojet, the energy of the propellant is increased by passing it over a resistance-heated element prior to expansion through a nozzle. In the arc jet, the working fluid is heated as it passes through and around an electrical discharge.

The principal problems in resistojet systems are in heat exchanger design and materials technology; these problems are limiting achievable specific impulse to values below 1,000 seconds. A contractor-designed 3-kilowatt steady-state resistojet was endurance tested for 300 hours at 3 kilowatts (scaling relations to higher powers were established in complementary AF programs). A series of thermal arc jets has been evaluated for operation with a variety of propellants, including helium, ammonia, and hydrogen at power levels ranging from 2 to 30 kilowatts. Successful endurance runs and the establishment of scaling relations to higher power resulted in a decision to deemphasize further major research on arc jets and resistojets for prime propulsion, pending a firm mission need.

In the research on electrothermal thrustors for station-keeping and

attitude-control applications, the extremely low-power resistojet is receiving primary emphasis. There are two basic concepts for the low-power resistojet thrustor—thermal storage and fast heat-up.

In the thermal storage resistojet, electrical power is continuously supplied to the heater element and only the propellant flow is pulsed. Such engines have relatively high-average-power consumption per thrustor, resulting in solar cell weights which may be prohibitive for a given mission. This disadvantage may be overcome by gimballing or developing multiaxis thrust pods to reduce the number of thrustors required; research on these systems is continuing.

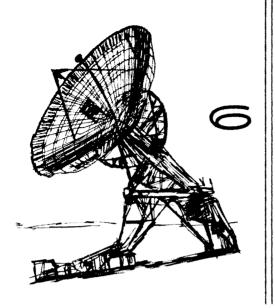
In the fast heat-up resistojet, both the power and propellant flow are pulsed. The primary advantage of this device is the low-average-power consumption. An extremely light-weight (50 milligrams) unit is being investigated for missions in the Applications Technology Satellite class. To illustrate the potential of this engine: a station-keeping and attitude-control system for a 550-pound satellite for a 3-year mission powered by this ammonia resistojet would weigh 85 pounds, while a low-thrust monopropellant chemical system of equivalent development status would weigh over 200 pounds.

Conceptually the most complex and technically the most difficult of the thrustors are the plasma devices; these are less developed than the electrothermal and electrostatic schemes. However, they hold promise of combining the high specific-impulse capability of ion engines with the high thrust of the electrothermal engines and thus justify study of their engineering feasibility.

Research was being conducted on two classes of devices, steady flow and pulsed, which differ primarily in the way the electrical energy is delivered to the accelerator. In plasma thrustors, an ionized gas is accelerated by the forces of interaction between currents within the gas and magnetic fields.

The most promising steady flow plasma accelerators are similar to the thermal arc jet, the difference being that the former involve large magnetic fields. In the self-induced magnetic field accelerator, the magnetic field arises from the high current discharge or arc itself, while in other devices an external magnetic field is applied to the discharge.

Research emphasis on the self-induced magnetic field accelerator has been relatively recent, arising from the first successful demonstration reported in the *Eleventh Semiannual Report*. A direct outgrowth of high current arc jet technology, this thrustor has attained specific impulses of over 10,000 seconds, greatly exceeding that achievable in purely electrothermal accelerators. Since the last period, this engine has run for periods in excess of 50 hours at a specific impulse of 10,000 seconds.



# TRACKING AND DATA ACQUISITION

The NASA tracking networks continued to provide excellent tracking, telemetry, command, and data processing support for the NASA and DOD flight programs during the last half of 1964. Major flight missions supported during this period included Ranger VII, Saturn SA-7, and the early phase of the Mariner IV flyby mission to the Planet Mars. There was a total of 19 launches, 3 of which were DOD satellites, during this period. In addition, the Space Tracking and Data Acquisition Network provided support to 15 satellites launched prior to this period.

To support future flight missions, the updating of the networks continued as planned. This updating included conversion of three stations in the Deep Space Network to the S-band frequency, the addition of a 40-ft. antenna to the Satellite Network, and the completion of the augmentation of the Manned Space Flight Network to support the Gemini program.

## Satellite Network

The Satellite Network includes the electronics Space Tracking and Data Acquisition Network (STADAN) operated by the Goddard Space Flight Center and 12 optical camera tracking stations operated by the Smithsonian Astrophysical Observatory. As indicated in the Eleventh Semiannual Report, the 13 STADAN stations are located at Blossom Point, Md.; Fort Myers, Fla.; Quito, Ecuador; Lima, Peru; Santiago, Chile; Woomera, Australia; Johannesburg, South

Africa; Goldstone, Calif.; St. Johns, Newfoundland; East Grand Forks, Minn.; Winkfield, England; Rosman, N.C.; and Fairbanks, Alaska.

The STADAN stations provide a tracking and data acquisition ground system designed to track satellites precisely, determine the status of each satellite, command its various functions, and acquire data from it. These stations have provided excellent support for all unmanned satellite programs, from the relatively unsophisticated early Explorer and Vanguard scientific satellites to the more complex Nimbus and Orbiting Geophysical Observatory satellites which were recently launched.

During this period, the operational capability of the Network was further extended by completion of the third medium-gain antenna installation at Santiago, Chile. (Fig. 6-1.) There are now three such installations with 40-foot parabolic dishes. (The first two were completed at Quito, Ecuador, and Johannesburg, South Africa, in May 1964.)

These antennas, together with the larger high-gain antennas (85-foot parabolic dishes), provide the Satellite Network with the capability to handle the larger and more complex scientific and weather satellites. The STADAN stations provided excellent coverage of the first Nimbus weather satellite, launched in August, and the first Orbiting Geophysical Observatory (OGO) satellite, launched in September. During the critical early orbit phases of Nimbus and OGO, real time operational control was possible at the Goddard Space Flight Center through the use of the recently added wideband data links to Rosman, N.C., and Fairbanks, Alaska.

In this reporting period, the Space Tracking and Data Acquisition Network supported 31 satellite programs. Sixteen of these were launched in this period:

Name	Date launched
1964 40C (TRS II)	July 17, 1964
1964 47A (Syncom III)	August 19, 1964
1964 48A (Starflash)	August 21, 1964
1964 51A (Explorer XX)	August 25, 1964
1964 52A (Nimbus I)	August 28, 1964
1964 54A (OGO-I)	September 5, 1964
1964 57A (Saturn I; SA-7)	September 18, 1964
1964 60A (Explorer XXI; IMP-B)	October 4, 1964
1964 64A (Explorer XXII; BE-B)	October 10, 1964
1964 74A (Explorer XXIII; S-55C)	November 6, 1964
1964 76A (Explorer XXIV/Air Density)	
1964 76B (Explorer XXV/Injun)	
1964 82A (Centaur 4)	
1964 83C (SN-43)	December 13, 1964
1964 84A (San Marco I)	December 15, 1964
1964 86A (Explorer XXVI)	December 21, 1964

Three of the above satellites (1964 40C, 1964 48A and 1964 83C) were Department of Defense Satellites.

The 12 optical tracking stations operated by the Smithsonian Astrophysical Observatory continued to provide backup support for NASA satellite programs. As indicated in the Eleventh Semiannual Report, these stations are located in San Fernando, Spain; Mitaka (Tokyo), Japan; Naini Tal, India; Arequipa, Peru, Shiraz, Iran; Curaçao,

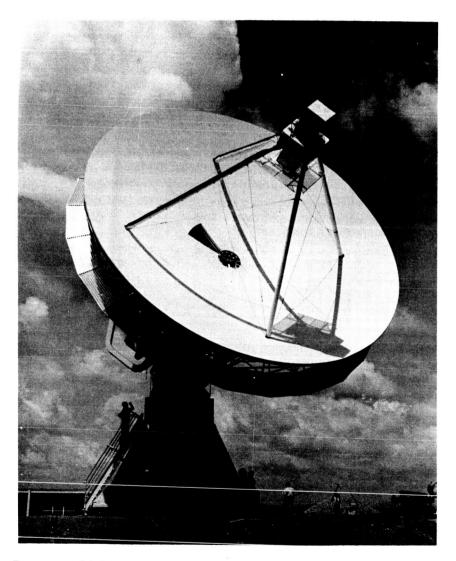


Figure 6-1. Medium-gain antenna installation, Johannesburg, identical to Santiago; Chile, installation.

Netherlands West Indies; Villa Dolores, Argentina; Mount Haleakala, Hawaii; Olifantsfontein, South Africa; Woomera, Australia; Jupiter, Fla.; and Organ Pass, N. Mex.

During this report period, the optical tracking stations provided orbital data for 21 satellites; they also tracked 15 satellites to obtain data for precise measurements of atmospheric and magnetic properties affecting satellite orbits.

# Manned Space Flight Network

The Manned Space Flight Network, now modified to support the Gemini program, is a more comprehensive and complex ground support system of stations than that required for Mercury manned space flights. The requirements for tracking two space vehicles simultaneously and the accuracy needed to insure safety of flight call for more comprehensive tracking equipment. These factors, plus the long-duration Gemini missions, require improvements in data acquisition, command capability, and communication.

The tracking and data facilities which have been augmented and modified to support the Gemini missions are Cape Kennedy, Fla. (including the Mission Control Center and Eastern Test Range stations at San Salvador Island, Grand Turk Island, Grand Bahama Island, and Antigua); Bermuda; Grand Canary Island; Carnarvon, Australia; Coastal Sentry Quebec (ship); Kauai, Hawaii; Rose Knot Victory (ship); Guaymas, Mexico; and Corpus Christi, Tex. The Mission Control Center (MCC) at the Manned Spacecraft Center, Houston, Tex., and the Control Center at the Goddard Space Flight Center, Greenbelt, Md., were also made ready for the Gemini flights. (Fig. 6-2.) Other stations in the network are Kano, Nigeria; Canton Island; White Sands, N. Mex.; Eglin, Fla.; Tananarive, Madagascar; and Point Arguello, Calif

The requirements for Gemini support necessitated expansion at the remote sites in both facilities and new equipment. The new equipment (radar, telemetry, command, communications, and displays) was integrated into the systems used for the Mercury Program.

Simultaneous acquisition and tracking of the Gemini spacecraft and the Agena vehicle is required because both objects may pass over a site simultaneously during critical phases of the mission. Additional radar displays and two PCM telemetry systems, including dual antennas, were installed at the primary stations to provide this capability. A telemetry display capability allows the station to select various data and display this data in real time.

Both HF and UHF links were established for communications reliability between the two astronauts and the ground station. Simultaneous communication with both astronauts can be accomplished by having one astronaut use the HF link while the other uses the UHF link. Additional ground communications circuits and facilities were installed to allow for proper automation of the equipment, remote control of various functions of the Mission Control Center (MCC) and transfer of mission control responsibility of the MCC from Cape Kennedy to Houston.

During the period under review, a major event supported by the Manned Space Flight Network was SA-7, launched on September 18, 1964. As pointed out in Chapter 1, SA-7 was a successful flight, demonstrating the S-I and S-IV propulsion systems. The flight also enabled NASA to evaluate the research and development tracking systems, both onboard and ground.

Planning, development, and implementation of the Apollo tracking and data acquistion network continued throughout this period. New facilities were being established and new and advanced electronic systems were being developed. The present Gemini network is to be augmented with new stations, antennas, command, telemetry, data processing, and communication systems. Coverage from water areas, too far removed from land-based equipment, is to be provided by instrumented ships and aircraft.

On December 11, 1964, the Centaur 4 was successfully launched from the Eastern Test Range. Tracking operations indicated that the 7,000-pound Centaur payload was orbiting the Earth at an altitude of approximately 105 miles.

Tracking support for Centaur is provided by the Manned Space Flight Network and the Deep Space Network.



Figure 6-2. Mission Control Center, Manned Spacecraft Center, Houston, Tex.

# Deep Space Network

The Deep Space Network is used primarily in support of NASA lunar and planetary programs. These stations are located at intervals of approximately 120 degrees longitude around the Earth to provide continuous tracking coverage for space flights. As indicated in earlier Reports, the Network has three permanent, operational tracking stations, located at Goldstone, Calif.; Woomera, Australia; and Johannesburg, South Africa. A mobile tracking station presently situated in South Africa, and a launch checkout station at Cape Kennedy, Fla., complete the Network. The Control Center is the Space Flight Operations Facility at the Jet Propulsion Laboratory (JPL) in Pasadena, Calif.

Construction of the S-band 85-foot antenna station located at Canberra, Australia, was completed and an operational checkout initiated. Construction continued on schedule for the S-band prototype 210-foot parabolic antenna station located at Goldstone, Calif., and the 85-foot antenna station located near Madrid, Spain.

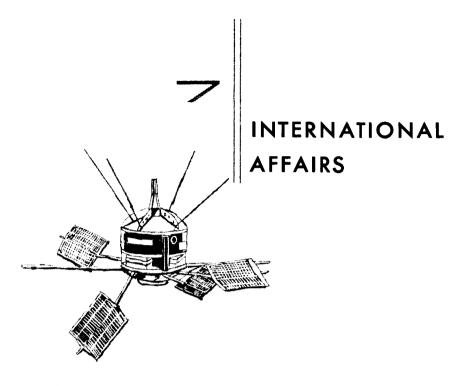
An interim system for the Woomera, Australia, and Johannesburg, South Africa, stations was completed. This system permits operation in the S-band frequency spectrum to support the Mariner C and D missions. These two stations will also be required to operate in the L-band frequency spectrum to support the Ranger C and D flight missions durin the early part of 1965.

The program of changing all stations in the Network for a fully operational S-band frequency capability was progressing as scheduled.

The Network tracked the Ranger VII spacecraft (Ch. 2) from shortly after injection into the lunar-transfer orbit (July 28) until lunar impact on July 31. The TV cameras operated for the final 13 minutes and 42 seconds, enabling the Goldstone station to receive and record excellent quality video data of the lunar surface. This video data, in turn, was developed into more than 4,300 photographs of the lunar surface. Some of the photographs received worldwide attention because of the clear definition of lunar surface impressions transmitted to the Goldstone stations.

The Deep Space Network is currently tracking and communicating with the Mariner IV spacecraft that is on a trajectory planned to carry it near the planet Mars on July 14, 1965. The Goldstone station successfully commanded a midcourse correction to Mariner IV 7 days after its launch.

Installation and checkout of mission-independent equipment for support of the Surveyor spacecraft flights for unmanned lunar landings were started.



During the last half of 1964, NASA's international activities were further expanded. A fourth international satellite was launched from a NASA facility, and numerous cooperative sounding rocket experiments were flown at foreign and domestic sites. Foreign experiments were selected for flight on future NASA satellites, and the United States reached an agreement with the Soviet Union to implement the exchange of meteorological data. Scientists around the world participated in experiments with Explorer XXII, foreign readout stations had an opportunity to utilize the Nimbus APT system, and NASA's communications satellites attracted additional international interest. Tracking stations in the Malagasy Republic and Nigeria provided increased operational support. Finally, the Agency continued the education and training in the United States of selected foreign space scientists and technicians.

# Cooperative Projects

This period was marked by achievements in cooperative space research projects with Argentina, Canada, Germany, India, Italy, Japan, New Zealand, Pakistan, Sweden, and the United Kingdom, including the launching of a fourth international satellite; by an agreement with the European Space Research Organization (ESRO)

for NASA to launch two ESRO scientific satellites; by arrangements with the U.S.S.R. to implement the exchange of meteorological data; and by approval of future cooperative efforts with France, the Netherlands, Norway/Denmark, and the United Kingdom.

### Argentina

The first scientific sounding rockets launched in South America through a NASA cooperative project were sent aloft from the Chamical range in Argentina on December 1 and 4. The payloads, designed to investigate the ionosphere, were constructed by Argentines at Goddard Space Flight Center. Two Nike-Cajun rockets purchased by the Argentines were used in these experiments.

#### Canada

In September, the Canadian-built, NASA-launched Alouette geophysical satellite entered its third year of providing useful scientific data. This has been one of the most successful satellite projects undertaken by NASA either individually or jointly with a foreign country.

# European Space Research Organization (ESRO)

A Memorandum of Understanding between NASA and ESRO, signed on July 8, provided for a cooperative project to launch two scientific satellites in 1967. The two ESRO-built and NASA-launched satellites will study the polar ionosphere and measure solar and cosmic radiation.

#### France

The FR-1 satellite, being constructed in France as part of a cooperative NASA-French National Center for Space Studies (CNES) effort, was scheduled for launching from the Western Test Range in late 1965. The engineering test unit and various subsystems of the satellite successfully underwent structural testing during the period. In November, representatives of NASA and CNES discussed coordinating independent NASA and French plans for data-gathering satellite programs and agreed to meet again early in 1965 for further discussion. Additionally, a French experiment was accepted for flight on board the OGO-E satellite to be launched in 1967.

# Germany

Under a cooperative agreement between NASA and the German Ministry for Scientific Research, sampling surfaces supplied by the Max-Planck Institute for Nuclear Physics were launched from White Sands, N. Mex., in November on an Aerobee sounding rocket. They were part of an Ames Research Center payload designed to collect atmospheric dust particles for laboratory analysis. Also, delegations from NASA and the German Ministry of Scientific Research discussed a proposed cooperative satellite project.

#### India

The sounding rocket range at Thumba, India, developed through cooperative projects with NASA, was recommended by a U.N. inspection team for U.N. sponsorship. When official U.N. approval is received (expected in the 1965 session), Thumba will become the first international range open for use by qualified agencies from all countries. In addition to NASA assistance, the range has received a launcher from France, and a recovery helicopter, a vibration test facility, and a computer from the U.S.S.R.

The Indians successfully launched three sodium vapor experiments from the Thumba range in November and December, as part of a cooperative NASA-Indian National Committee for Space Research (INCOSPAR) project. (Fig. 7-1.)

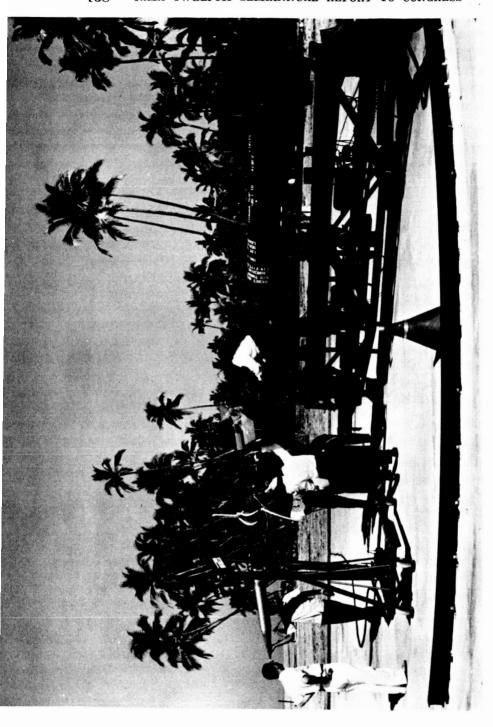
#### Italy

On December 15, Phase II of the San Marco project was completed with the orbiting of the first San Marco satellite by a Scout vehicle from Wallops Island. The launching was conducted by an Italian crew trained at the NASA installation. The principal scientific experiment of the satellite, designed by the Aeronautical Research Center of the University of Rome, measured the density of the upper atmosphere in the vicinity of the satellite. The secondary experiments, designed by the University of Florence, measured electron content and radio wave propagation in the upper atmosphere. The final phase of the program, Phase III, will involve the launching of an identical satellite into an equatorial orbit from a platform in the Indian Ocean off the coast of Kenya.

# Japan

The last in a series of four cooperative sounding rocket experiments was launched in October at Wallops Island, Va. The instrumentation to measure electron density and temperature distribution was provided by the Radio Research Laboratory of the Ministry of Posts and Telecommunications, Tokyo.





#### **Netherlands**

A Memorandom of Understanding between the Netherlands Organization for the Advancement of Pure Research and NASA was signed on July 10. It calls for a cooperative sodium vapor sounding rocket project with launchings scheduled to take place from Surinam in September 1965. In addition, arrangements were made for the Netherlands to prepare and fund a cosmic ray experiment to fly on board the OGO-E satellite to be launched in 1967.

#### New Zealand

As part of a cooperative project with the United States, New Zealand launched two Arcas sounding rockets from Birdling's Flat, New Zealand, in September and December. Purpose: To measure atmospheric temperature and pressure and electron density for comparison with ground measurements of ionospheric electrical turbulence.

# Norway/Denmark

A Memorandum of Understanding was signed July 16 by the Norwegian Space Research Committee, the Ionospheric Research Laboratory of the Royal Technical Institute of Denmark, and NASA. By providing for a new series of sounding rocket launchings in the spring of 1965, it extended the program of ionospheric investigation initiated in 1961.

#### **Pakistan**

Pakistan continued launching small sounding rockets as part of two cooperative projects with NASA. Included were eight Judi-darts to measure high altitude wind direction and intensity and two Nike-Apaches to conduct sodium vapor release experiments.

#### Sweden

Under an agreement between the United States and Sweden, four sets of sounding rocket payloads were launched from the Kronogard Range in Northern Sweden during this reporting period. In each case, a grenade payload to measure upper atmospheric temperature, density, and winds was launched in coordination with a sampling payload to collect noctilucent cloud particles. Reduction and analysis of data from the flights will not be completed for several months, but the experiments are believed to have obtained useful scientific data.

# United Kingdom

The first foreign experiment included on a NASA satellite was a mass spectrometer experiment prepared by University College, London, and launched on Explorer XX, August 25 (pp. 49-51). Two British experiments to measure electron temperature and density and to study energetic photons in primary cosmic rays were accepted for flight on board the NASA OGO-E satellite. This makes a total of eight British experiments to be flown on five NASA satellites. The University of Birmingham, England, provided an electron temperature experiment for two University of Illinois sounding rocket payloads launched from Wallops Island, Va., in July and November.

#### U.S.S.R.

On November 5, NASA and the Soviet Academy of Sciences reached agreement on a Second Memorandum of Understanding to implement the Bilateral Agreement of June 8, 1962. This cleared the way for the exchange of conventional and satellite meteorological data, when available from both sides, over a special communications link between Moscow and Washington. Regular exchange of conventional data began on November 16.

# Ionospheric Beacon Satellite

International participation in NASA's polar ionospheric beacon satellite, Explorer XXII, launched in October, was the most extensive of any single satellite project to date. Experimenters included scientists in 27 countries, stations in Antarctica and Greenland, and laser tracking in France and the United Kingdom. Sixty-one foreign stations are making observations. Data obtained will be collected by the Goddard Space Flight Center and made available to the world scientific community.

# Nimbus/APT Meteorological Projects

Extensive international interest also focused on the Automatic Picture Transmission (APT) subsystem for direct readout of cloud cover pictures which was flown for the second time on the Nimbus satellite launched in August. Photographs of regional cloud cover systems were received by 17 foreign stations. (Fig. 7-2.)

# International Indian Ocean Sounding Rocket Meteorology

Cooperative projects developed by NASA to supplement the atmospheric studies of the International Indian Ocean Expedition resulted

in coordinated launchings of more than 12 meteorological rockets by India, Pakistan, and Australia during established world geophysical intervals.

#### Opportunities for Future Cooperation

Copies of "Opportunities for Participation in Space Flight Investigations" were sent to foreign space committees, interested foreign scientists, scientific attaches in Washington, and the U.S. embassies abroad. In this brochure, NASA renewed invitations to the world scientific community to submit experiments for flight on NASA's manned and unmanned spacecraft on a self-supporting basis.

#### Distribution of Range VII Photographs and Film

Sets of Ranger VII photographs and prints of a 7-minute movie made from the Ranger photographs were furnished to scientific attaches in 16 U.S. embassies for distribution and showings to foreign scientific groups.

# **Operations Support**

During this period, the United States received increased operational support from the Malagasy Republic and Nigeria. Also, interna-

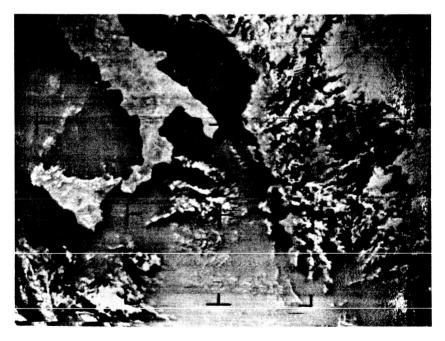


Figure 7-2. APT cloud cover picture.

tional support was provided for the Syncom III and Relay communications satellites and for Project Gemini.

# Malagasy Republic

The relocated NASA tracking and data acquisition station in Madagascar became operational. This station was transferred from Majunga to Tananarive and expanded to include support for Project Gemini as well as unmanned scientific satellites. President Tsiranana of the Malagasy Republic visited the Goddard Space Flight Center in July.

# Nigeria

The data acquistion station at Kano, previously used only in conjunction with Project Mercury, was equipped to support some of the NASA scientific satellites (Alouette, the Ionospheric Explorer, and the launching phase of Syncom III). Also, a plaque commemorating Nigerian support of Project Syncom was presented by the American Ambassador to the Nigerian Minister for Communications on September 15.

#### Communications Satellites

Successful live television of the Olympic games was carried via Syncom III from Japan to the United States in October. In November, an inaugural demonstration program was transmitted from the United States via Relay to the new communications satellite ground station at Rao, Sweden (a joint venture of Denmark, Norway, and Sweden). And arrangements were made with India for its possible participation in the experimental communications satellite program.

# Contingency Recovery

Arrangements were being made with a number of governments for the stationing of aircraft in their territories for contingency recovery of astronauts and spacecraft during Project Gemini launchings early next year.

# Cooperation Through International Organizations

#### United Nations

In October and November, the Deputy Administrator of NASA, Dr. Hugh L. Dryden, served as technical adviser to the U.S. representative to meetings of the United Nations Committee on the Peaceful

Uses of Outer Space. The Assistant Administrator for International Affairs served as alternate U.S. representative. During the meetings of the Legal Subcommittee, which immediately preceded those of the full Committee, the NASA General Counsel and Deputy General Counsel were members of the U.S. delegation.

# Personnel Exchanges, Education, and Training

During the last half of 1964, over 1,600 foreign nationals from 72 countries visited NASA facilities for scientific and technical discussions or general orientations. Visitors included representatives of space programs in Argentina, Australia, Canada, Germany, India, Italy, Switzerland, and the United Kingdom, as well as representatives of ESRO and ELDO (European Launcher Development Organization).

Under the NASA International University Fellowship Program, 64 graduate students from 16 countries studied space sciences at 17 American universities with the support of their national agencies and the European Space Research Organization. This program is administered by the National Academy of Sciences. Also, 65 post-doctoral and senior postdoctoral associates from 21 countries carried on research at NASA centers, including the Jet Propulsion Laboratory. This program is also administered by the National Academy of Sciences (with JPL administering its own program) and is open to U.S. nationals. Eighteen foreign students, sponsored by their national or regional space committees, attended a summer institute in space physics at Columbia University under NASA sponsorship.

Seventy-four technicians from Italy and ESRO, here at their own expense, received training in space technology at Goddard Space Flight Center and Wallops Station in connection with agreed cooperative projects.



# GRANTS AND RESEARCH CONTRACTS ACTIVITIES

Since its establishment in 1958, NASA has sought to enlist the university community in its research programs, for it is this group which has been a primary source of scientific, technological and administrative manpower and of the creative ideas, skills, and techniques essential for the success of the national space effort. The NASA-university relationship, which centers chiefly about specific basic and applied research projects, is the responsibility of the Office of Grants and Research Contracts (OGRC). OGRC receives, handles, distributes, and, working in close cooperation with other NASA elements, evaluates and sponsors research. It also coordinates the reviews and evaluations of NASA field centers and Headquarters project offices, and oversees the issuance and provides for administration of research grants and contracts to nonprofit scientific and educational institutions. In addition, this office has administrative responsibility for the Sustaining University Program.

# The Sustaining University Program

The NASA Sustaining University Program was designed to increase the participation of the university community in aeronautical and space science and to take advantage of the unique ability of the

universities to conduct the broad, multidisciplinary research required for the national space effort. To achieve its aims (increase the supply of scientists and engineers with space-related training, provide urgently needed laboratories for space research, and encourage multidisciplinary research, develop new capabilities, and consolidate space-related activities) the Sustaining University Program is structured into Training, Facilities, and Research components.

# **Training**

A major effort of the Sustaining University Program is predoctoral training. Grants are awarded to universities for expanding and accelerating the training of scientists and engineers in the space-related fields, and also to help universities strengthen and broaden their graduate programs in science and technology. Grants are awarded for a 3-year period.

Of the 1,957 predoctoral students at 131 institutions (appendix T), 1,071 began work for the Ph. D. as NASA trainees in September. The disciplines represented by these students are shown in the following table.

Discipline	Fiscal year 1962	1963	1964
	Percent	Percent	Percent
Physical sciences	59	47.8	52. 0
Engineering	32	41.5	34.8
Life sciences.	5	7.8	8. 5
Behavorial sciences	3	2.9	4. 1
Other	1		. 6
Total number of students	100	786	1, 071

In December, 142 institutions were notified of their selection for participation in the fiscal year 1965 program; 11 of these will be participating for the first time.

Thirty-eight of the students participating in this program have received their doctorates, earning degrees in physical sciences (23), engineering (9), life sciences (3), behavioral sciences (2), and other areas (1). They have gone into university research and/or teaching (24), postdoctoral scholarships or Fulbright fellowships (5), government laboratories (3), and industrial laboratories (6). Thus, approximately three-fourths of the students trained under NASA sponsorship have remained in the university world to carry on basic research and assist in training other students.

#### Research Facilities

Facilities grants to universities now total 27. The following seven, with a total value of \$5,889,000, were awarded during the period of this report:

University of Southern California	\$160,000
Cornell University	1,350.000
Purdue University	840,000
New York University	582,000
University of Arizona	
University of Illinois	1,125,000
Polytechnic Institute of Brooklyn	632,000

These seven new grants will make possible the design and construction of a portion of the research space required by universities for the more efficient conduct of an extremely broad and complex program of research supporting our space effort.

The renovation and additions for the Human Centrifuge Facilities at the University of Southern California will enable this facility to expand its present services to university and NASA researchers in their studies of humans and animals subjected to the strains of space travel. During this period, data derived from operating the centrifuge was used in designing the larger human centrifuge at the Ames Research Center.

At the Cornell University Center for Radiophysics and Space Research, where NASA supports lunar and solar systems research, atmospheric and ionospheric studies, and space vehicle instrumentation investigations, facilities were being designed to provide more efficient laboratories for this advanced research.

Design of new rocket motor test facilities was nearing completion at the Purdue University Jet Propulsion Center. These facilities will enhance the university's capability for chemical propulsion research and also enable graduate students to receive space-related scientific and technological training.

The Aerospace Laboratory at New York University, which was in the design stage, will provide special facilities for advanced research in hypersonic flow, shock layer instability, radioactive transfer, advanced propulsion systems, astrophysical phenomena, and other facets of high-speed aerodynamics and propulsion.

The University of Arizona's Space Sciences Center design neared completion. The Center will accommodate a substantial portion of NASA-supported research in lunar mapping, lunar surface studies, spectroscopic studies of the planets, and instrumentation for rocket flight experiments.

The University of Illinois Aerospace Research Center, which was

under design, will complement facilities of the Coordinated Sciences Laboratory and promote university wide, NASA-supported research in such fields as general relativity, low-pressure measurement, properties of thin films, surface and plasma physics, and ionspheric measurements by rocket probes.

Design of the Aerospace Research Facilities for the Freeport campus of the Polytechnic Institute of Brooklyn was completed, bids were awarded, and construction was started. These facilities will increase research capabilities on topics such as lifting vehicles at high Mach numbers, discrimination of reentry vehicles, high-lift and high-drag vehicles returning from orbit, disturbances in the ionosphere, and optimal flight plans for interplanetary vehicles and satellites.

The Space Sciences Laboratory at the University of Chicago was completed and occupied (fig. 8-1). This structure, one of the first constructed under a grant awarded by NASA, enabled various space-related research activities to be consolidated into a single building. It has specialized facilities for low-level radiation counting, cosmic ray experiments, data processing, and preparation of balloon and rocket experiments.



Figure 8-1. Space Sciences Laboratory, University of Chicago.

The Propulsion Sciences Laboratory of the Guggenheim Laboratories at Princeton University was completed and the cornerstone placed in October (figs. 8-2(a) and 8-2(b)). These facilities house research in combustion processes and instability, plasma physics, and chemical, nuclear, and electrical propulsion.

The foregoing structures together with the annex to the Harvard cyclotron and the Minnesota addition to its physics building (figs. 8-3(a) and 8-3(b)), brought the total of completed research laboratories to four. In addition, 11 others were in varying stages of design; of the 12 under construction, UCLA, M.I.T., and Polytechnic Institute of Brooklyn (PIB) initiated construction during this period. The satus at the end of this period of all facilities under construction is shown in the following table.

Institution	Topic	Percent complete
RPI Stanford Iowa U. of Calif. (Berkeley) M.I.T Colorado UCLA Michigan Pittsburgh Lowell Observatory Washington University PIB	Materials Exobiology Physics and Astronomy Space Science Space Science Astrophysics Space Science Space Science Space Science Planetary Science Physics Aeronautics	95 35 65 20 5 30 20 60 65 90

#### Research

The Research element of the Sustaining University Program seeks to expand and increase the capabilities of the Nation's universities to conduct research responsive to the needs of the space program. It does this by encouraging multidisciplinary activities, unified research programs, new and promising research, and more comprehensive investigations to fill gaps between related projects.

During this period, 25 multidisciplinary research programs, chiefly fundamental and long range in nature, were in progress. Several have been in operation long enough to exemplify the effect this broad and flexible form of support can have upon research development.

A grant at the University of Florida for "Multidisciplinary Research in Space-Related Science and Technology," stimulated radio-astronomical observations of the S-66 satellite, low-frequency observations of radio emissions from the planet Jupiter, and research in nuclear astrophysics, magnetofluid mechanics, nuclear propulsion problems, and radiation in planetary atmospheres.

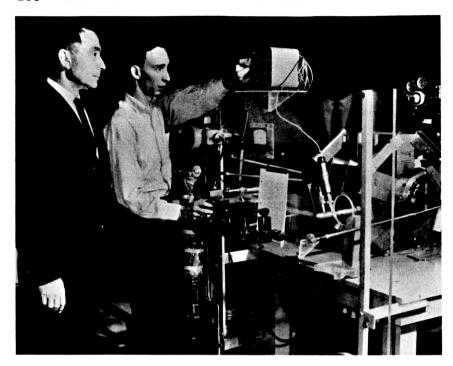


Figure 8—2(a). Plasma research equipment, Propulsion Sciences Laboratory, Princeton University.

At the University of Maryland the program in the application of high-speed computers to space-related research problems continued to make significant advances. The results of pattern recognition studies were applied to the analysis of TIROS cloud cover pictures, and a newly developed comprehensive programing system for crystallographic structure analysis proved to be extremely valuable for accurately determining the arrangement of atoms in the crystal lattice.

UCLA conducts a broad program of space-related research in the physical and biological sciences and in engineering. A NASA grant supported projects for the collection of meteoroids in space, for the design and fabrication of a unique testing chamber for spacecraft magnetometers, and for the development of a very high-power inductively coupled plasma generating device. Research continued in astronomy, geochemistry, materials, fuel cells, animal sensory signals, biological rhythms, and research management problems.

Research grants at the California Institute of Technology, the Graduate Research Center of the Southwest, and the University of California, Berkeley, supported fundamental research resulting in the development of new flight experiment designs and an improved capa-



Figure 8-2(b). Exterior of Propulsion Sciences Laboratory, Princeton University.

bility to process, interpret, and evaluate data received from space satellites and probes. Materials research at the University of Denver, astrophysics at Montana State College, and engineering research in structures at Texas A. & M., supported by grants from this program, continued to contribute to their research areas. At the College of William and Mary and the University of Virginia, fundamental research continued in high-energy physics; this work is keyed to the eventual utilization of the 600 Mev. synchrocyclotron at NASA's Langley Research Center.

Research on the conversion of different forms of energy into electricity by "unconventional" means, including thermoelectric, thermionic, and similar devices, as well as magnetohydrodynamics and fuel cells, was being conducted with NASA support at the University of Pennsylvania. Studies were in progress on biochemical fuel cells, plasma physics, thermionics, and thermal energy storage.

At the University of Wisconsin, advanced research continued. Studies in theoretical chemistry, particularly molecular quantum and statistical mechanics, were directed toward determining the physical and chemical properties of materials, the relation of these properties to properties of individual molecules, and the structure and properties of the individual molecules.

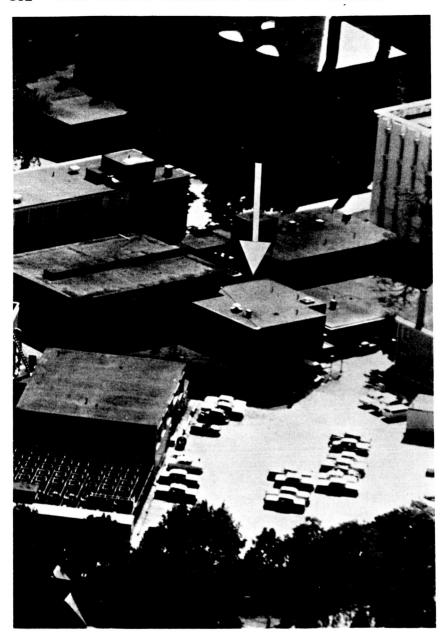


Figure 8-3(a). Harvard cyclotron annex.

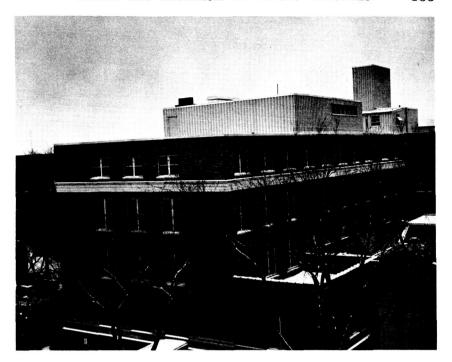


Figure 8-3(b). Minnesota physics building addition.

In addition, new research programs were initiated at the University of Louisville and the University of Missouri. The University of Louisville grant for "Space-Related Research in Polymer and Bio-Organic Chemistry," will deal largely with laser-based studies of the behavior of bio-organic and polymeric materials under conditions related to the extraterrestrial environment. The grant to the University of Missouri will support projects in energy conversion and utilization, physical properties of materials for use in the space environments, and environmental biology—particularly the adaptation of living organisms to unusual environmental conditions.

During this period, six Sustaining University Program grants were made to three institutions (Columbia University, New York University, and Yale University) working in direct cooperation with the Goddard Space Flight Center's Institute for Space Studies.

# Resident Research Associate Program

Under the NASA-National Academy of Sciences Resident Research Associates Program, approximately 60 scientists held appointments at Goddard Space Flight Center, Ames Research Center, and the Marshall Space Flight Center. Plans were made for the Lewis Research Center and the Manned Spacecraft Center at Houston to participate in this activity in 1965.

# Management of Grants and Research Contracts

The new system of financial management reporting and control of cash requirements under active grants (described in the Eleventh Semiannual Report, p. 157-8) became operational. It was used in planning for implementation of Treasury Department Circular No. 1075, which prescribes the Letter of Credit Method of Financing for all grant programs. Tentative internal procedures were prepared, and two major universities agreed to participate in a pilot systems study. The principal objective of the Treasury Department is to minimize cash advances to grantees and schedule advances according to the actual cash needs of the recipient.



# INFORMATIONAL AND EDUCATIONAL PROGRAMS



During the last 6 months of 1964, NASA expanded its specialized informational-educational activities and services and improved its methods of disseminating scientific and technical information. Examples of projects in the former area included helping colleges and universities plan space science courses and arranging summer workshop services for teachers. In the latter area, the Selective Dissemination of Information program became fully operational as it initially supplied 500 NASA scientists and engineers with prompt announcements of selected, job-related technical reports and journal literature.

# Educational Programs and Services

The Agency engaged in adult education projects to help the public understand the national space program. In addition, NASA's space-mobile lecture-demonstration teams supplied information on space sciences and exploration to more than 1.7 million school children, to teacher training programs, and to civic groups. Its spacemobile lecturers appeared on TV before 10 million viewers.

The Agency joined the University of Colorado in sponsoring a national conference at the Manned Spacecraft Center on November 22 to 24. Purpose of the conference was to acquaint university administrators of summer sessions with the space program and to

determine how NASA might assist the educational institutions which they represent. Four regional conferences were also held during the report period. These were at Langley Research Center (September 21 to 22) for area science supervisors; at Ames Research Center (August 11 to 13) for educators and guidance personnel under the National Defense Education Act; at the Manned Spacecraft Center (November 16 to 17) for guidance personnel; and finally an aerospace education conference for development of space science materials at Goddard Space Flight Center (August 31 to September 4).

To meet instructional needs of schools, colleges, and universities in space science and technology, NASA helped to develop educational materials at all levels. For example, in cooperation with the National Science Teachers Association and with various college aerospace institutes, the Agency developed supplements to classroom teaching in space-related science and mathematics. In addition, the following materials were published and distributed: A syllabus for an adulteducation lecture series developed by the Rhode Island State Department of Education; six science guides for elementary teachers prepared in cooperation with the National Science Teachers Association; detailed plans for science and industrial arts teachers to use in building models of NASA's space vehicles; and information on careers in space science and technology for guidance counselors and teachers. Further, "educational briefs" for teachers were developed and published by the Manned Spacecraft Center and Goddard Space Flight Center.

NASA also disseminated space science information by means of college and university extension services and summer workshops for teachers. More than 275 colleges and universities were assisted in planning space science courses, and summer workshop services were arranged for about 14,000 teachers.

In addition, the Agency helped to increase public understanding of the Nation's space program by participating in adult education programs. For example, the adult education pilot project in the public schools of Warren, R.I. ("Mankind and Space"), undertaken by NASA and the Rhode Island State Department of Education, determined the feasibility of conducting this type of space sciences program at some distance from the resources of an Agency research center. A report on the project was published and made available to state departments of education, local school districts, YWCA's, and others interested in adult education.

In its youth programs, NASA cooperated with the National Science Teachers Association to complete plans for holding the second annual series of youth science congresses in early 1965. Basic plans were also completed with Science Service for science fair programs

during the spring of 1965 and the Science Fair—International to be held in St. Louis, Mo., in May 1965. The Agency also provided facilities for the Sixth National Model Rocket Championships meeting at Wallops Island, Va., in August 1964. Fifty young people from various sections of the country participated.

#### Spacemobiles

During the report period, 25 spacemobile lecture-demonstration teams provided information on NASA's space science and exploration programs for more than 1.7 million schoolchildren, for teacher training programs, and for civic groups. In October, 3 new units were added to bring the total lecture-demonstration units in this country to 28. Spacemobile lecturers also made 14 radio presentations, and their 60 television appearances supplied space information for over 10 million TV viewers.

Special spacemobile activities included participation in the Michigan State Curriculum Conference, the Pacific Science Center in Seattle, the "Parade of Progress" Space Program in Cleveland, the Illinois Educational Association, the Louisiana Teachers Association, the Threshold of Space Symposium at the University of Minnesota, and in special programs for crippled children and deaf children in Dayton, Ohio. Spacemobile programs also continued to explain the Agency's space program to teachers and students in Central and South America, Europe, and Africa.

#### Educational Publications and Films

NASA released several new publications, issued updated editions of previously published ones, and reprinted a number of articles from periodicals—all available to requestors without charge. In addition, the Agency made substantial progress in planning and producing a number of motion pictures for distribution to the general public without cost. Publications and films currently available are described in appendix N.

Film Depository Services.—By the end of the report period, NASA had catalogued and stored 6,255, 899 feet of motion picture film. About 42,000 feet of film was made available to producers of educational and documentary movies and telecasts.

#### Educational Television and Radio

Six half-hour documentary educational TV programs on "Space: Man's Great Adventure" were completed and sent to educational and commercial television stations on request. The programs were recorded on video tape at NASA centers and include reports on the experiments of rocketry pioneer Dr. Robert H. Goddard; activities on a Saturn launch pad; development of docking and lunar landing simulators; research and development of V/STOL and other types of aircraft; role of a woman scientist in the space program; and use of satellites in locating and tracking hurricanes. Films of these programs will be distributed through NASA libraries to schools and educational groups.

"Aeronautics and Space Report," a 5-minute monthly film series for television and other educational uses, was developed and the first program produced. Using available stock film footage, these reports will include brief educational features on developments in aeronautics and space programs. Beginning in January 1965, the programs will be made available to all interested educational and commercial TV stations for use on documentary, news, or instructional telecasts. Prints of these programs will also be available through NASA libraries for schools and other educational groups.

A television and radio production aids library was established to loan film clips, slides, photographs, and audio tapes to educational and commercial stations for instructional or documentary programs. Assistance was also given to about 1,000 requestors in planning and presenting space-related programs on local television and radio stations. In addition to these production aids, models, spacemobile demonstrations, stock film footage, and program participants were provided.

Educational radio activities were also increased substantially. For example, "Space Story," a weekly 5-minute report on space activities, was provided to many requesting radio stations. Tapes of this series were made available through NASA libraries to schools, science clubs. and other educational groups. Recordings were being made for a series of 13 half-hour radio documentaries on bioastronautics for students of psychology and medicine as well as for general audiences. To be completed by July 1965, these programs will be released to requesting radio stations and to educational institutions.

A new series of interviews and commentaries by managers of various space projects and other space authorities was begun for distribution to requesting educational and commercial stations. This service will provide timely information to students and the general public. Assistance was also provided to several hundred educational and commercial radio stations in presenting space information on local programs. In addition, a national radio network was assisted in producing a weekly radio series on space subjects.

# Artists\* Cooperation Program

Under its Artists' Cooperation Program, NASA originally assigned eight nationally recognized painters to record their impressions of Astronaut Cooper's 22-orbit flight of Project Mercury, May 15-16, 1963. (See the Ninth Semiannual Report to Congress, pp. 3 and 149.) During 1964, seven additional artists joined in this program to record Agency activities of current public interest and of historical significance. Participating artists include Peter Hurd, Lamar Dodd, John W. McCoy, II, Paul Calle, Robert McCall, Mitchell Jamieson, Robert Shore, George Weymouth, Theodore Hancock, Morris Graves, Dong Kingman, Hugh Laidman, Fred Freeman, Paul Sample, and A. McAdams. The National Gallery of Art will help NASA select the best from the hundreds of paintings and sketches produced and assist in planning for their first exhibition.

#### **Exhibits**

During the period, NASA's 194 exhibitions reached 8,758,000 people in the United States, Canada, Puerto Rico, and the Philippine Islands. Principal solo exhibits were the "Man in Space" exposition at Philadelphia during which 40,000 students visited and attended space



Figure 9-1. Parade of Progress Exposition, Cleveland, Ohio.

science lectures, and the "Parade of Progress" at Cleveland attended by over 540,000. These expositions highlighted the successful missions of Ranger VII, Nimbus I, Syncom III, and the first Orbiting Geophysical Observatory. (Attendance at the U.S. Space Park of the New York World's Fair reached 1.5 million for the season ending on October 18.) Space educational exhibits were also displayed in weekend "open houses" at Langley Research Center, Lewis Research Center, as well as in the space fair at Pacific Launch Operations and at the Allegheny State Fair, Pittsburgh, Pa.

# Scientific and Technical Information

The second 6 months of 1964 saw new high levels of accomplishment attained in all aspects of NASA's operations in its scientific and technical information program. Increased activities and services centered around the—

- Publication of formal reports of research results;
- Acquisition, cataloging, indexing, abstracting, and announcement of aerospace technical reports and scientific journal articles from all sources;
- Distribution of documents in printed, facsimile, and microfiche (sheet microfilm) form;
- Servicing of reference requests from NASA laboratories and contractors;
- Preparation of requested and continuing bibliographies;
- Periodic distribution of magnetic-tape indexes to the NASA technical information collection; and
- Computer-based express announcement of selected documents to individuals.

#### International Activities

The volume of aerospace scientific and technical literature from foreign sources acquired for NASA and national use increased markedly during this reporting period. This literature, in technical-report form and as published journals, books, monographs, and articles, is obtained by exchange and technical-data sharing arrangements. The Agency has technical cooperation agreements with 23 governments and 3 international organizations, and publications exchange arrangements with 195 individual organizations in 38 countries. These include government agencies, professional societies, academic institutions, research institutes, and libraries.

To bring the entire world's aerospace literature to the attention of NASA's scientists and engineers and the varied audiences served by the Agency, all technical reports are abstracted and announced in NASA's abstract journal Scientific and Technical Aerospace Reports (STAR). All formally published literature (articles in scientific and technical journals, papers presented at scientific meetings, books, monographs, and other publications) is made available to the American Institute of Aeronautics and Astronautics for abstracting and announcement in its NASA-supported International Aerospace Abstracts (IAA).

During 1963, 4,200 foreign information items were abstracted, announced, or otherwise made available as full-size or microfiche documents. In the following year, 7,200 foreign items were similarly provided to NASA field centers, contractors, and other organizations participating in aerospace programs. A large proportion of this material is sold to the public by the Clearinghouse for Federal Scientific and Technical Information, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Va., 22151. The increase in information thus made available is illustrated by the fact that in 1963 NASA released 319 translations of foreign aerospace literature through the Department of Commerce and 522 of these translations during 1964.

#### Public Sale of Microfiche

During the report period NASA also began providing to the Clearinghouse for Federal Scientific and Technical Information, for public sale, microfiche copies of unclassified NASA reports announced in STAR. The sale of NASA reports in this form (a 4-by 6-inch sheet carrying 60 images to a page) is in addition to the usual printed or facsimile copies of these documents available from the Clearinghouse. In addition, all noncopyrighted literature abstrated in *International Aerospace Abstracts* was made available for sale in microfiche form from the Technical Information Service, American Institute of Aeronautics and Astronautics, 750 Third Avenue, New York, N.Y., 10017.

#### Selective Dissemination of Information

NASA's Selective Dissemination of Information (SDI) Program became operational. As phases of the program were developed and evaluated, operational responsibility was transferred to the Agency's Scientific and Technical Information Facility. Information covered by the program was expanded to include IAA in addition to STAR. Initially, 500 scientists and engineers at NASA headquarters and about 200 in the U.S. Air Force and field centers began receiving prompt announcement of selected job-related technical reports and journal literature. Selection of reports and journal items is made by

computer matching of index terms with the participant's "interest profile"—subject terms and phrases related to his work and interests.

#### Technical Publications

As the volume of NASA's scientific and technical literature expanded, the Agency increased its efforts to enhance the professional quality and usefulness of these publications. Because so much of NASA's research and development work is performed under contract, particular emphasis was placed on improving the usefulness of contractor-generated research reports which serve as one of the most important inputs into the Agency's information system. The thousands of contractors and grantees reporting on thousands of research investigations produce a variety of technical and editorial standards which could offer serious difficulty in indexing, abstracting, retrieval, and reproduction unless measures were established to attain reasonable uniformity. In pursuit of this objective, the Scientific and Technical Information Division brought out three guides during the period:

- "Preparing Contractor Reports for NASA: Repro Typing and Layout;"
- "Prepjaring Contractor Reports for NASA: Tecchnical Illustrating;" and
- "Clarity in Technical Reporting."

In addition, NASA developed preliminary specifications for scientific report preparation which will be incorporated into future research and development contracts.

The Agency also sought to improve the usefulness of its own scientific and technical literature. Research reports from NASA's flight and research centers have reflected the various presentation standards of each. The "NASA Publications Manual," issued during this period, is designed to achieve substantial uniformity in the Agency's scientific reporting. A second, closely related development was the establishment of an Agency-wide format for scientific texts, tables, and graphs.

Among the several hundred scientific reports released during the last 6 months of 1964 were:

- "Physics of Nonthermal Radio Sources" (NASA SP-46);
- "Proceedings of the AAS-NASA Symposium on the Physics of Solar Flares" (NASA SP-50);
- "Quasi-Global Presentation of TIROS III Radiation Data" (NASA SP-54); and
- "Concepts for the Detection of Extraterrestrial Life" (NASA SP-56).

The most unusual publication of the period was "Ranger VII Photographs of the Moon: Part I" (NASA SP-61), an atlas-quality reproduction of 199 large lunar photographs taken by a wide-angle camera during the last 17 minutes before Ranger VII impacted on the moon on July 31, 1964. A selected list of these reports and other NASA scientific publications is provided in appendix O.

# Historical Program

Major projects of NASA's historical staff during this report period were: the "Administrative History of NASA"; "Astronautics and Aeronautics: Chronology on Science, Technology, and Policy: 1964"; "Space Medicine in Project Mercury"; "Chronology of Major NASA Launchings"; and projects in NASA's Centers such as a history of Project Mercury.

Published during the period were: "Astronautics and Aeronautics: Chronology on Science, Technology, and Policy: 1963" (Superintendent of Documents, U.S. Government Printing Office for \$2); "History of Rocket Technology" (edited by NASA's historians and issued by the Society for the History of Technology, Wayne State University Press, Detroit, Mich.); and "Six Years of NASA" (issued on the Agency's anniversary).

Major activities of the Agency's historians also included:

- Support of the John F. Kennedy Memorial Library at Harvard University by supplying selected documents, releases, publications, photographs, and films, and interviewing key NASA scientists and other leaders in the Nation's space program.
- A summer graduate Seminar on History, Social Science and Space with students of American University, University of California (Berkeley), Yale University, and Case Institute.



PERSONNEL,
MANAGEMENT,
PROCUREMENT,
AND
SUPPORT
FUNCTIONS

In those areas which support its increasingly complex scientific and technical missions, NASA continued making substantial progress. It further strengthened the personnel program through better employee-management cooperation, through expanded training activities for its employees, through recognition of individual achievements and contributions, and through balanced recruitment and placement efforts. Necessary organizational changes were made, steps were taken to assure even more effective management of financial affairs, and further improvements of the procurement functions were stressed.

#### Personnel

The overriding purpose of NASA's personnel program is to promote competent and economic use of its staff and total work force, to the end that the Nation's space goals and objectives are met, while expenditures and man-hour uses are kept within minimum limits. As the following paragraphs indicate, progress toward achieving this purpose was made during this period.

# **Employee-Management Cooperation**

NASA activity in the Government-wide Employee-Management Cooperation in Federal Service (Executive Order 10988) increased in scope and volume. Exclusive recognition was granted to local employee organizations at two NASA installations: at the Lewis Research Center, the American Federation of Government Employees; and at the Langley Research Center, the International Association of Machinists. Also, the Goddard Space Flight Center and the Washing-

ton Area Metal Trades Council concluded negotiations, and their collective agreement was approved by the NASA Administrator.

# Training Activities

A 2-day Management Seminar was developed to teach NASA managers the basic management concepts and operating philosophy of the Agency. Major topics include the annual authorization/appropriation process; the budget execution process; R. & D. project planning and approval process; management reporting and review process; the procurement process; and agencywide management policies, systems, and procedures.

A 1-day Executive Management Orientation on incentive contracting was developed. This seminar provides the NASA executive with an opportunity to develop an understanding of his role in the application of incentive features to the various NASA procurement programs.

Continued emphasis was given to the established seminars and training programs. These include the NASA-PERT and Companion Cost System Seminar, the Conflict of Interest and Standards of Conduct Training Program, the Procurement Management Seminar, the Quality Assurance Training Program, the Graduate Study Program, the Cooperative Education Program, and the Management Intern Program.

# Equal Employment Opportunity

The Agency continued implementing the Affirmative Action Program for Federal Employment as required under Executive Order 10925. As pointed out in the Eleventh Semiannual Report, this program is intended to assure better use of manpower resources by reassignment of minority group employees who are presently underutilized, by increased employment of qualified minority group persons, and by seeking to interest Negroes and other minority group persons to qualify for scientific and engineering positions available with NASA and other Government agencies.

To increase the effectiveness of the Affirmative Action Program, NASA installations continued to implement the tasks cited in the previous report. In addition, the following new activities were developed and adopted by NASA's installations: (1) Administrative Co-op training, using minority students from adjacent colleges; (2) more intensive recruiting of qualified minority students at integrated schools by conducting preplacement sessions at minority fraternities, sororities and social clubs; (3) distributive education programs, using minority students from adjacent high schools; and (4) increased mi-

nority participation in our co-op training program by negotiating additional training agreements with qualified minority schools.

# Status of Women Program

In compliance with Executive Order 10980, all NASA installations were directed to develop affirmative action programs for the appointment and career development of qualified women in scientific, technical, and administrative positions.

Since April 1964, 2 percent of all appointments to GS-9 and above positions were women; 3.8 percent of all promotions at GS-9 and above were women. As of June 30, 1964 the total female employment in NASA in grades GS-9 and above was 3.7 percent.

#### Manpower Research and Utilization

An analytical study of selected characteristics and background of scientists and engineers hired by NASA during the 2 years preceding September 30, 1964, was completed. This study is a followon of a similar study completed in 1963 on scientists and engineers hired during the 15 months preceding September 30, 1962.

# Status of Personnel Force

NASA increased its staff from 32,499 to 33,108 during the period from June 30 to December 31, 1964. The distribution by installation was:

Organization:	June 30, 1964	Dec. 31,
Ames Research Center		2, 215
Electronics Research Center*	33	*117
Flight Research Center	619	622
Goddard Space Flight Center	3, 675	3, 640
John F. Kennedy Space Center, NASA	1,625	1, 880
Langley Research Center	4, 330	4, 329
Lewis Research Center	4,859	4, 878
George C. Marshall Space Flight Center	7, 679	7, 639
Manned Spacecraft Center	4, 277	4, 721
Pacific Launch Operations Office	22	21
Wallops Station	530	523
Western Operations Office	376	386
Headquarters	2, 158	2, 026
(AEC/NASA) Space Nuclear Propulsion Office	112	111
Total	32, 499	33, 108

<sup>\*</sup>The NASA Electronics Research Center, Cambridge, Mass., was established Sept. 1, 1964. It absorbed the staff of the former North Eastern Office, also at Cambridge, Mass.

# Key Executive Personnel Changes

During the period, a number of personnel changes occurred within NASA's staff of key executives. They were as follows:

Key Appointments.—On August 3, Everett E. Christensen was appointed as Special Assistant to the Associate Administrator for Manned Space Flight. On December 20, he was reassigned to the new position of Director of Mission Operations, to direct and coordinate the flight operations of both the Gemini and Apollo programs. Mr. Christensen came to NASA from the position of Development Test Manager in the Missile Systems Division of the Lockheed Missiles and Space Corp., Burbank, Calif. He had been associated with Lockheed since 1953.

Merrill H. Mead was appointed, on August 30, as Director, Program and Resources Division within the Office of Advanced Research and Technology. He had served as Chief of Technical Program Planning at the NASA Ames Research Center since 1956. (He had been associated with Ames since 1947.)

Dr. Winston E. Kock was appointed Director of the new Electronics Research Center, Cambridge, Mass. (September 1). Since 1962, Dr. Kock had served as Vice President for Research with the Bendix Aviation Corp. (he had been associated with Bendix since 1956). From 1942 to 1956, he was Chief Scientist with the Bell Telephone Laboratories, Murray Hill, N.J.

On September 1, 1964, Gen. William F. McKee was appointed as Assistant Administrator for Management Development. General McKee retired from the U.S. Air Force on August 1, after more than 35 years of service. From 1962 until his retirement, he was Vice Chief of Staff of the Air Force.

William B. Rieke was appointed (November 1) as Deputy Associate Administrator for Manned Space Flight (for Management). Mr. Rieke came to NASA from the position of President, Lockheed Aircraft International. He had been associated with the Lockheed corporation since 1941.

Dr. Charles F. Yost was appointed as Director, Technology Utilization Division on November 1. He came from the Advanced Research Projects Agency (ARPA), Department of Defense, where he had been Director of Materials Sciences.

On December 1, 1964, Lt. Gen. Frank A. Bogart was appointed to the position of Special Assistant to the Associate Administrator for Manned Space Flight. Before retiring from active service in November (1964), General Bogart had served as Comptroller of the Air Force.

On December 18, 1964, Dr. Lester C. Van Atta was appointed as

Assistant Director for Electromagnetics Research, NASA Electronics Research Center; he entered on duty January 4, 1965. Dr. Van Atta came from the position of Chief Scientist with the Lockheed Missiles and Space Co., Sunnnyvale, Calif., which he had occupied since 1962. From 1950–62 he served as Director of Research Laboratories, Hughes Aircraft Co.

Dr. W. Crawford Dunlap, Jr., was appointed (December 18) as Assistant Director for Electronic Components Research, NASA Electronics Research Center. Before coming to NASA, Dr. Dunlap was Director of Solid State Electronics Research, Raytheon Research Division, Waltham, Mass. He had served in this capacity since 1958.

Reassignments.—On May 19, 1964, Dr. Alfred J. Eggers, Jr., formerly Assistant Director for Research and Development Analysis and Planning, NASA Ames Research Center, was appointed Deputy Associate Administrator for Advanced Research and Technology, NASA Headquarters. Dr. Eggers had been associated with the NASA Ames Center since 1944.

On October 11, Mr. Charles W. Harper was appointed as Director, Aeronautics Division, within the Office of Advanced Research and Technology. Mr. Harper had served at Ames Research Center since 1941 and as Chief of the Full-Scale and Systems Research Division since 1959.

Mr. Breene M. Kerr was made Assistant Administrator for Technology Utilization on November 22. He joined NASA June 1, 1964, as Deputy Assistant Administrator for Technology Utilization. Prior to that time he had been associated with the Kerr-McGee Oil Industries, Inc.

Terminations.—Dr. Eugene B. Konecci resigned October 24 from the position of Director of Biotechnology and Human Research within the Office of Advanced Research and Technology. He had served in this capacity since July 1962.

Robert B. Young resigned (October 30) from the position of Director, Industrial Operations, at the NASA George C. Marshall Space Flight Center. He had served in this capacity since November 1963, when the Office of Industrial Operations was established at Marshall.

On December 30, Robert J. Lacklen resigned from the position of NASA Director of Personnel. He had served in this capacity since October 1, 1958, and in the same capacity with the former National Advisory Committee for Aeronautics since 1948.

Dr. George M. Knauf resigned from the position of Deputy Director of Space Medicine, Office of Manned Space Flight, on December 31. He had served in this capacity since his retirement from the U.S. Air Force in November 1962, and had previously served in this same capacity on detail from the Air Force prior to his retirement.

#### NASA Awards and Honors

Special honorary recognition was given to individuals and groups for their contributions to the Nation's space program.

NASA Medal for Outstanding Leadership.—Four individuals received this award:

Kurt H. Debus, John F. Kennedy Space Center: For his outstanding contributions to space technology through his pioneering leadership, technical innovations, and insistence upon meticulous teamwork, thus greatly advancing this Nation's launch capability.

Harry J. Goett, Goddard Space Flight Center: For his outstanding service as the director of a complex scientific organization. His many achievements have contributed to the preeminent position of this country in the pursuit of scientific knowledge, the development of space technology, and the application of such research and development to the benefit of mankind.

Wernher von Braun, Marshall Space Flight Center: For his ability to inspire his associates to sustained excellent performance in the development of space launch vehicles of unprecedented power and reliability, culminating in the seven successful launches of the Saturn I.

R. P. Young, Headquarters: In recognition of his outstanding leadership and dedicated service displayed in all aspects of performance while serving as Executive Officer of NASA and for his significant and noteworthy contributions in coordinating internal management of the Agency.

NASA Medal for Exceptional Scientific Achievement.—The following four individuals received this award:

William R. Lucas, Marshall Space Flight Center: For his superior scientific accomplishments in the solution of unprecedented problems in the broad field of materials science and engineering as applied to launch and space vehicles.

Daniel G. Mazur, Goddard Space Flight Center: For exceptional technical achievement in the development of communications satellites and associated ground-systems which placed the United States in a position of leadership in the practical use of satellites for world communications.

Frank B. McDonald, Goddard Space Flight Center: For his major scientific contributions to the study of solar proton events, the interplanetary medium, and the galactic cosmic radiation as project scientist and principal experimenter on Explorer XII, Explorer XIV, and IMP-A; and for his significant technological assistance in understanding the radiation environment in space.

Ernst Stuhlinger, Marshall Space Flight Center: For his excep-

tional scientific accomplishments in aerospace programs which included invaluable contributions to electric propulsion, to management of supporting research and advanced technology programs, and to lunar scientific exploration.

NASA Exceptional Service Award.—The following five individuals received this award:

Oran W. Nicks, Headquarters: For his exceptional ability in directing NASA's lunar and planetary space flight program, and especially for his contribution to the Ranger program which obtained the world's first high resolution photographs of the lunar surface.

Leonard Jaffe, Headquarters: For his exceptional ability in planning and implementing the NASA communications satellite program, leading to the remarkable achievements of the Echo, Relay, and Syncom communications satellites.

Wesley L. Hjornevik, Manned Spacecraft Center: For his exceptional ability in establishing and operating an effective business management organization in the newly created Manned Spacecraft Center, and particularly for his role in the design and construction of the Center's facilities within the prescribed time and budget limitations.

I. Edward Garrick, Langley Research Center: For his pioneering work in scientific research in the field of aeronautical and astronautical structural dynamics; and for his exceptional ability in assembling, educating, and administering an outstanding research organization in this field.

Hans F. Gruene, Kennedy Space Center: For his exceptional ability in developing and directing the immediate launch team responsible for the preparation, checkout, and launch of complex vehicles—culminating in seven consecutively successful research and development flight tests of the Saturn I, the Nation's largest vehicle to date.

NASA Special Service Award.—This award went to Newton W. Cunningham, Headquarters, for his demonstrated high degree of technical and managerial abilities and efforts that led to the successful Ranger IV flight to the moon and obtained the world's first high resolution photographs of the lunar surface.

NASA Group Achievement Award.—Group awards were presented to the following two installations:

Kennedy Space Center: For exceptional achievement in the preparation, checkout, and successful launches of Saturn I, the first generation of the Nation's most powerful launch vehicles.

Marshall Space Flight Center: For exceptional achievement in conceiving, designing, and developing the Saturn I.

Presidential Citations.—Twenty-two individuals and seven organizational elements received this award based on an outstanding con-

tribution to greater economy and improvement in Government operations. They were as follows:

Name or organization	Installation
J. L. Burch	Marshall Space Flight Center.
Vincent N. Capasso, Jr	Flight Research Center.
Parker L. Carroll	Manned Spacecraft Center.
B. Chovan	Marshall Space Flight Center.
John Cresap	Marshall Space Flight Center.
Joseph Darr	Flight Research Center.
Carl Erbscorn	Marshall Space Flight Center.
Leslie E. Foster	Marshall Space Flight Center.
William J. Franklin (two awards)	Marshall Space Flight Center.
W. L. Kimmons	Marshall Space Flight Center.
Frank J. Lalli	Lewis Research Center.
Lawrence R. Madigan	Lewis Research Center.
Neil Martin	Marshall Space Flight Center.
E. L. Martz	Marshall Space Flight Center.
William R. Potter	Marshall Space Flight Center.
John E. Reeves	Flight Research Center.
A. E. Schuler	Marshall Space Flight Center.
Robert J. Schwinghamer	Marshall Space Flight Center.
Jack Trott	Marshall Space Flight Center.
Ed Williams	Marshall Space Flight Center.
Mark L. Wright	Lewis Research Center.
Analysis and Computation Division	Langley Research Center.
Industrial Resources Division	Headquarters.
Instrument Construction Shop Section,	Langley Research Center.
Mechanical Services Division.	
Mechanical Services Division	Langley Research Center.
MTF Working Group, Test Laboratory	Marshall Space Flight Center.
Research Models and Facilities Division	Langley Research Center.
Space Mechanics Division	Langley Research Center.

Outside Honorary Awards.—The following four significant honorary awards were presented to NASA personnel:

Harmon International Trophy: L. Gordon Cooper, Astronaut, Manned Spacecraft Center: For overcoming mechanical failure to guide his FAITH 7 space capsule to a safe landing in May 1963.

Lewis W. Hill Award: Dr. Hugh L. Dryden, Deputy Administrator, NASA, Washington, D.C.: For his personal contribution to fluid mechanics research leading to the space era, and for his personal contribution to the X-15 research airplane program.

Hermann Oberth Medal: Dr. Ernst Stuhlinger, Marshall Space Flight Center: For meritorious contributions to the space field.

Gen. Thomas D. White Space Trophy: L. Gordon Cooper, Astronaut, Manned Spacecraft Center: For the most outstanding contribution to the Nation's program in aerospace during 1963.

## Inventions and Contributions Board

As was pointed out in the previous report, NASA's Inventions and Contributions Board has three functions, two of which are statutory. It considers the petitions of NASA's contractors for waiver of patent rights in inventions made by their employees. It evaluates for possible monetary award scientific and technical contributions received from all sources, whether made by NASA employees, contractor employees, or persons not affiliated with NASA programs. And it makes monetary awards for NASA employee inventions. See appendix I for membership of the Board.

### Patent Waiver Petitions Granted or Denied

During this period, the Inventions and Contributions Board processed 53 petitions for waiver of patent rights, recommending that 48 be granted and 5 be denied; 12 of these were given final action during the period. (See appendix J.) In addition, a list of waivers granted and denied by the Administrator upon recommendation of the Board is included in appendix K.

Revised Patent Waiver Regulations published in the Federal Register on August 27, 1964, became effective on September 28, 1964. All petitions for waiver of patent rights received on or after October 20, 1964, will be considered under the Revised Patent Waiver Regulations.

#### Contributions Awards

Under the provisions of the Space Act of 1958, the NASA Inventions and Contributions Board evaluates scientific and technical contributions and recommends to the Administrator the amounts and terms of the awards to be made for any found to have significant value in the conduct of aeronautical and space activities. During this period the Board received 1,533 communications and evaluated 625 new contributions. From such evaluations, the agency granted four awards, as listed in appendix L.

#### Invention Awards

Under the provisions of the Incentive Awards Act of 1954, the NASA's Inventions and Contributions Board is authorized under its own cognizance to make monetary awards, in amounts not to exceed \$5,000, for patentable inventions made by NASA employees. Twenty such awards were made during the second half of 1964. (See appendix M.)

# NASA Patent Program

NASA's patent program, administered by the Office of General Counsel, is concerned with receiving, evaluating, and protecting inventions made in the course of NASA activities; providing overall guidance on patent and data questions raised in connection with NASA procurement activities; and handling matters relating to NASA infringement of privately owned patents. During the past 6 months, NASA initiated a foreign patent program and issued new patent waiver regulations implementing the October 1963 President's Statement on Government Patent Policy.

## Foreign Patent Program

NASA initiated a foreign patent program on a trial basis. Under this program, the Agency is filing patent applications in countries other than the United States on selected inventions in which it has acquired the principal or exclusive rights. The objective of this program is to extend the patent coverage on valuable NASA-owned inventions to various foreign countries in furtherance of the interests of U.S. industry and the Government. Fifty-two patent applications were filed and were pending before the Patent Offices of foreign countries.

## Revised Patent Waiver Regulations

The NASA patent regulations regarding the disposition of rights in inventions resulting from NASA research and development contracts were revised to reflect the policy guidelines established by the President's Statement of October 10, 1963. This statement identifies basic considerations and criteria to be followed in determining rights which Government agencies should acquire in inventions made under their grants and contracts.

All agencies were directed to follow the policy guidelines outlined in the statement within the scope permitted by statute and to the extent consistent with their missions. Implementation of the statement required revision of both the NASA Patent Waiver Regulations (14 CFR 1245.100) and Part 9 of the NASA Procurement Regulations.

# Organizational Improvements

The Agency made four significant organizational improvements during the period. (Fig. 10-1.) These were the establishment of the electronics research center, the realinement of manned space flight

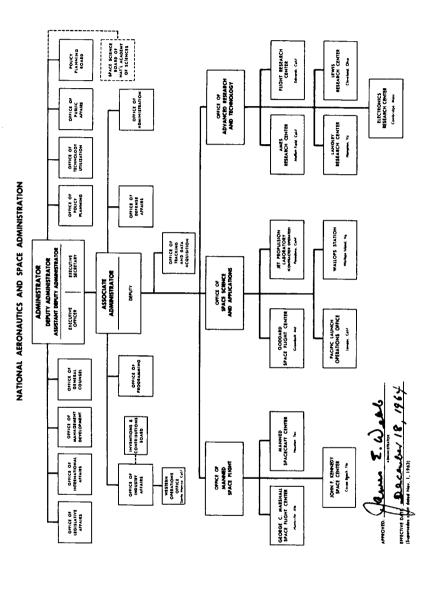


Figure 10-1. NASA organization chart (Dec. 18, 1964).

operations functions, the appointment of a European representative, and the appointment of an Assistant Administrator for Technology Utilization.

# Electronics Research Center Established

On September 1, 1964, the Electronics Research Center was established at Cambridge, Mass., absorbing the activities of NASA's Northeastern Office in Cambridge. The Center's research activities will include basic studies and research in instrumentation, communications, data processing, navigation, and guidance and control. Its Director reports to the Associate Administrator for Advanced Research and Technology at NASA Headquarters.

## Realinement of Manned Space Flight Operations Functions

To prepare for the expected increase in the number of manned space flights and to meet requirements for concurrent Gemini and Apollo launch schedules, mission operations functions within NASA's Manned Space Flight organization were realined.

A new position, Mission Operations Director, established within the Headquarters' Office of Manned Space Flight, replaced the former position of Deputy Associate Administrator for Manned Space Flight Operations. The Mission Operations Director is responsible for the overall planning, coordination, and direction of all activities in the conduct or support of missions in manned space flight programs. He is supported by three mission directors who will be assigned to individual missions and by staff groups to coordinate support requirements within NASA and between NASA and other Government agencies.

The Manned Spacecraft Center's Florida Operations Office at Cape Kennedy was merged with the Kennedy Space Center organization. This transfer consolidates at the Kennedy Center responsibility for assembly, checkout, and launch of manned spacecraft in addition to launch vehicles.

Realinement of these functions simplifies and strengthens organizational responsibilities and relationships between the NASA Centers and offices directing, managing, and supporting the manned space flight effort.

# European Representative Appointed

A European Representative was appointed to handle NASA relations with Western European regional and national space organizations on cooperative projects and other joint international space

activities. This representative, stationed in the U.S. Embassy in Paris, reports to the Assistant Administrator for International Affairs in NASA Headquarters.

## Assistant Administrator for Technology Utilization Appointed

The former Assistant Administrator for Technology Utilization and Policy Planning was relieved of his technology utilization responsibilities, allowing him more time for the duties of his positions as Assistant Deputy Administrator and as Assistant Administrator for Policy Planning. His former deputy was named Assistant Administrator for Technology Utilization, with full-time operating responsibility for that program.

# Financial Management

NASA improved its financial management activity in a number of ways during the period.

Mechanized procedures were installed for the preparation of Headquarters operating budgets, the consolidation of total NASA budget estimate figures, and the preparation of reports comparing actual obligations with those planned. This mechanization significantly reduced the number of man-hours required to perform these operations (previously all were manual operations).

NASA's in-house manpower utilization reporting system was revised on July 1. The system now provides for mechanized integration of data reported in terms of man-months of effort, with dollar data derived from the same source (formerly reported through a separate system). Steps were taken to further refine the system on January 1, 1965, providing man-hour in lieu of man-month data input to permit more realistic presentation of selected program effort.

A series of 1-week contract cost management seminars was under development. These seminars will provide basic instruction to project personnel. The instruction will cover the financial aspects of contract management, industrial organization and financial relationships, industrial accounting systems, cost forecasting and cost projections, the control of overhead costs, industrial financial statements, and cost control reports. It will also include industrial aspects such as corporate profit motives, inventory and personnel management and cost control, and the interpretation and analysis of contractor cost reports.

Program financial reporting systems were revised so that field installations need to submit only current-period information. Cumulative data is now provided by a refined Data Bank system which also makes available, through automatic data processing procedures, inte-

grated financial and statistical contractual information formerly produced on a manual recording and reporting basis.

A survey of the cost accrual, accumulation, and distribution practices of the field installations was completed. Similar reviews were being made of the cost reporting and estimating systems used by some of NASA's principal contractors. The information derived from these reviews well be used in implementing and improving the NASA Contractor Cost Reporting System.

## Fiscal Year 1966 Program

Table 1 shows the planned level of effort in research, development, operation, and construction of facilities for fiscal year 1966.

Table 1.—NASA budget estimates, fiscal year 1966 [In thousands]

Research and development:	
Gemini	\$242,100
Apollo	2,997,385
Advanced mission studies	10,000
Physics and astronomy	172,100
Lunar and planetary exploration	215,615
Sustaining university program	46,000
Launch vehicle development	63,600
Launch vehicle procurement	194,500
Bioscience	31,500
Meteorological satellite	42,700
Communications satellites	2,800
Applications technology satellites	28,700
Basic research	22,000
Space vehicle systems	35,000
Electronic systems	34,400
Human factor systems	14,900
Nuclear-electric systems	27,000
Nuclear rockets	58,000
Chemical propulsion	30,000
Solar and chemical power	14,200
Aeronautics	42,200
Tracking and data acquisition	246,200
Technology utilization	5,000
Total, research and development	4,575,900
Construction of facilities	74,700
Administrative operations	609,400
Total	5,260,000

## Financial Report, December 31, 1964

Table 2 shows funds obligated and disbursed during the first 6 months of fiscal year 1965. Appended is a summary by appropriation showing current availability, obligations against this availability, and unobligated balances as of December 31, 1964.

Table 2.—Status of appropriations as of Dec. 31, 1964
[In thousands]

Appropriations	Obligations	Disburse- ments 1
Research and development:		
Gemini	<b>\$16</b> 8,605	\$120,132
Apollo	1,699,862	1,119,988
Advanced missions	8,063	6,443
Completed missions	-298	1,264
Geophysics and astronomy	54,379	54,946
Lunar and planetary exploration	111,040	95,433
Sustaining university program	9,022	8,100
Launch vehicle development	50,370	50,794
Unmanned vehicle procurement	51,777	60,637
Bioscience	13,605	8,216
Meteorological satellites	9,831	15,736
Communications satellites	1,401	5,193
Applications technology satellites	16,094	7,789
Manned space sciences	4,477	1,201
Research program.	7,882	9,229
Space vehicle systems	19,694	19,642
Electronic systems	10,271	10,309
Human factor systems	7,091	6,326
Nuclear electric systems	20,373	19,066
Nuclear rockets	32,810	37,922
Chemical propulsion	37,955	25,990
Space power	6,476	5,006
Aeronautics	8,875	9,301
Tracking and data acquisition	111,275	116,508
Technology utilization	1,078	1,651
Operations	-386	2,550
Reimbursable	45,087	25,518
Total, research and development	2,506,709	1,844,890
Construction of facilities	320,466	247,006
Administrative operations	297,358	277,173

<sup>&</sup>lt;sup>1</sup>This column lists all disbursements made during the current fiscal year regardless of when the funds were obligated and excludes appropriation reimbursements deposited.

Appropriation summary	Current availability <sup>2</sup>	$Total \ obligations$	Unobligated balance
Research and development	\$4,699,101	\$2,506,709	\$2,192,392
Construction of facilities		320,466	488,984
Administrative operations	627,483	297,358	330,125

<sup>&</sup>lt;sup>2</sup> The availability listed includes anticipated reimbursable authority.

## Cost Reduction

The Agency's cost reduction effort during the period showed measurable savings of \$100,369,000. The support being given to the effort throughout the organization indicates that the goal for fiscal year 1965, \$175 million, should be met or exceeded. (Significantly, during fiscal year 1964, the program achieved actual economies of \$128,783,000 against a goal of \$81,780,000.)

Thirty-one of NASA's contractors voluntarily agreed to participate in the cost reduction program with the view of effecting increased efficiency and economy in the performance of their NASA contracts. First contractor reports were expected in early February 1965.

# Procurement and Supply Management

In the overall area of procurement and supply management, NASA improved certain of its policies and procedures, issued directives to modify some of its procurement practices, and continued its emphasis on incentive contracting.

#### Procurement Policies and Procedures

NASA's procurement policies and procedures were updated during the period, as indicated by the publication of new directives and the establishment of new or modified guidelines pertaining to particular methods or courses of action.

Independent Research and Development.—NASA recently established an informal procedure for participating with the Department of Defense in negotiating advance agreements with major contractors for the reimbursement of independent research and development costs. Both the Armed Services Procurement Regulation and the NASA Procurement Regulation provided for the allowability of this cost under certain specific conditions. To assure proper allowance for such reimbursements, major contractors are encouraged to negotiate advance agreements. Such a procedure was established by the Department of Defense in 1960. Since NASA is doing business with many of the same major contractors and since our procurement regulations are substantially the same, it is more economical and consistent to become partners in these negotiations.

Upon completion of the negotiation, copies of the report of the agreement are distributed to all procuring activities of the Department of Defense and the National Aeronautics and Space Administration. This makes possible uniform treatment of major contractors by the NASA as well as the DOD without duplicating the administrative effort.

NASA Policy and Procedures For Use of Excess Foreign Currencies.—NASA established a new policy relating to its procurement relationships with foreign countries, with respect to the balance of payments. Through this policy (set forth in a new regulation), NASA ensures that contracts and other obligations incurred in certain countries (Burma, India, Indonesia, Israel, Pakistan, Poland, United Arab Republic, and Yugoslavia) are made payable in foreign excess currencies rather than U.S. dollars (BOB Bulletin 64–3 dated Sept. 14, 1963). The expenditure of foreign excess currencies rather than U.S. dollars in these countries provides a saving in the budget and improves the balance of payments situation.

Issuance of "NASA Source Evaluation Board Manual" (NPC 402).—The Agency's basic policy concerning use of Source Evaluation Boards for competitive negotiated procurements, regulations for the establishment of such Boards, and procedures governing evaluation and selection of contractors was set forth in a new manual issued in August ("NASA Source Evaluation Board Manual"). The new manual presents detailed procedures for guiding Source Evaluation Boards in developing criteria and rating systems, evaluating sources, and presenting their reports to the selection official. Results, already noted by the Administrator in recent Board reports and oral presentations, reflect more meaningful rating systems and more thorough evaluations.

Procurement of Potentially Hazardous Items.—In September, NASA revised a procurement regulation, adding a requirement that contractors and subcontractors furnish to NASA complete design information and drawings, showing all details of construction, including materials, for those items or components which are designated as potentially hazardous. (This followed an X-248 rocket motor accident at Cape Kennedy and a subsequent Accident Review Board report.) Each invitation for bids and request for proposal must contain such requirements; each procurement request calling for the delivery of a potentially hazardous item must so state and require that detailed design information and drawings be furnished; a specific "Rights in Data for Potentially Hazardous Items" clause must be included in NASA contracts; and policies and procedures are prescribed for procuring potentially hazardous items from or through other Government agencies.

Policy Against Discrimination on Basis of Age.—NASA changed a procurement regulation (Part 12, Subpart 10) to provide that contractors and subcontractors performing Federal contracts shall not discriminate against persons because of age, except on the basis of a bona fide occupational qualification, retirement plan, or statutory requirement. This policy extends to the employment, advancement, or

discharge of employees; it embraces the terms, conditions, and privileges of employment.

This change was made to implement Executive Order 11141 of February 12, 1964 (29 F.R. 2477), declaring a new public policy on the subject. The Order was designed "to encourage and hasten the acceptance of the principle of equal employment opportunity for older persons by all sectors of the economy, private and public."

Cost Sharing Contracts.—NASA issued a new regulation setting forth its policy of limiting the use of cost sharing contracts to research and development procurements where there is a probability that the contractor will receive present or future commercial benefits.

Reduction of Letter Contracts.—NASA's policy limiting the use of letter contracts was modified, further restricting issuance of letter contracts, regardless of dollar amount, except in individual cases which the Associate Administrator had approved in advance. December reports of existing letter contracts, NASA-wide, indicated that there are only 3 letter contracts outstanding as of the end of November (11 were outstanding at the end of June).

The FEDSTRIP Program.—As of October 1, all NASA supply activities adopted the Federal Standard Requisitioning and Issue Procedure (FEDSTRIP) for obtaining supplies from the General Services Administration Depots (GSA). Through these procedures, NASA expects to reduce the effort and paperwork involved in supply requisitioning by (1) using ADP or EAM equipment to automatically initiate requisitions on punched cards; (2) simplifying funding procedures; (3) reducing administrative handling of requisitions; and (4) reducing document preparation. FEDSTRIP is making it possible to obtain required supplies on a more timely basis.

Federal Catalog System in NASA.—NASA was integrating the Federal Catalog System into its supply operations. Approximately 85 percent of the 120,000 items in the NASA installation supply systems have been identified with Federal item identifications, including Federal Stock Numbers. The conversion of all supply control records, bin tags, and stock catalogs to the use of these Federal Identifications was in process, and was expected to be completed by July 1965.

# Incentive Contracting

NASA was continuing to pursue its policy of using incentive arrangements appropriate to the circumstances in all possible procurement actions to reduce and control costs. During the period, incentive contracts increased from 54, amounting to approximately \$541 million, to 68, amounting to \$725 million. An additional 11 contracts were in

the process of negotiation which would then bring the total to \$1,588 million.

The Agency was attempting to convert major cost-plus-fixed-fee contracts to incentive types providing the conversions would be to its advantage.

A revised and updated Incentive Contract Guide was being prepared for use in the basic training courses on incentive contracting. In addition, plans were being made to develop refresher courses and courses suitable for middle management training in this area. And in a continuing effort to provide field personnel with timely and responsive assistance in their conduct of the incentive program, a specialist in incentive contracting was added to the Office of Procurement.

### Summary of Contract Awards

NASA's procurements for the first 6 months of fiscal year 1965 totaled \$2,928 million. This is 51 percent more than was awarded during the corresponding period of fiscal year 1964.

Approximately 82 percent of the net dollar value was placed directly with business firms, 1 percent with educational and other nonprofit institutions and organizations, 4 percent with the California Institute of Technology for operation of the Jet Propulsion Laboratory, and 13 percent with or through other Government agencies.

Contracts Awarded to Private Industry.—Ninety percent of the dollar value of procurement requests placed by NASA with other Government agencies resulted in contracts with industry awarded by those agencies on behalf of NASA. Also, about 74 percent of the funds placed by NASA under the Jet Propulsion Laboratory contract resulted in subcontracts or purchases with business firms. In short, about 96 percent of NASA's procurement dollars was contracted to private industry.

Sixty-eight percent of the total direct awards to business represented competitive procurements, either through formal advertising or competitive negotiation. An additional 11 percent represented actions on followon contracts placed with companies that had previously been selected on a competitive basis to perform the research and development on the applicable project. In these instances, selection of another source would have resulted in additional cost to the Government by reason of duplicate preparation and investment. The remaining 21 percent included contracts for facilities required at contractors' plants for performance of their NASA research and development effort, contracts arising from unsolicited proposals offering new ideas and concepts, contracts employing unique capabilities, and procurements of sole source items.

Small Business Participation.—Small business firms received 5 percent of NASA's direct awards to business. Excluding the 20 largest awards which were for major systems and hardware requiring resources not generally within the capability of small business on a prime contract basis, small business received 16 percent of the total awards to business.

Participation in Subcontracts.—In addition to the \$114 million of direct awards from NASA, small business received \$218 million in subcontract awards. These subcontract awards include \$189 million from 46 large business firms participating in NASA's Small Business Subcontracting Program and \$29 million from the Jet Propulsion Laboratory of the California Institute of Technology. Thus, small business received a known amount of \$332 million of NASA's dollars during the 6 months plus an undetermined amount from other NASA prime contractors and from other Government agencies, including the Department of Defense, on behalf of NASA. The \$332 million constituted 13 percent of NASA's awards to business and JPL during the period.

Geographical Distribution of Prime Contracts.—Within the United States, NASA's prime contract awards were distributed among 44 States and the District of Columbia. Business firms in 40 States, and educational and other nonprofit institutions in 40 States participated in the awards. Seven percent of the awards were placed in labor surplus areas located in 18 States.

Subcontracting.—Subcontracting effected a further distribution of the prime contract awards. Eighty-one of NASA's major prime contractors located in 23 States reported that their larger subcontract awards on NASA effort had gone to 1,466 different subcontractors in 45 States and that 59 percent of these subcontract dollars had crossed State lines.

# Technology Utilization

During this reporting period, NASA's Technology Utilization Program stressed identification of new technology. It also refined and expanded its efforts to disseminate technical information to potential users.

A new technology clause continued to be added to all new NASA research and development contracts and to existing ones when renewed. This clause, as revised, requires the contractor to report all new technology in the form of patents, innovations, and advances in the state-of-the-art. The administration of this clause, including an expanding program of contractor education about its requirements, led to a substantial increase in contractor reporting of new technology developments.

Many new developments were published in the form of "Tech Briefs" and other Technology Utilization publications. As of December 31, 220 Tech Briefs had been published and disseminated. They covered five main fields: electrical, energy sources, materials, mechanical, and life sciences.

Steps were taken to make sure that scientific and technical trade journals and other news media received appropriate information on "Tech Briefs" and other technology utilization publications. By year's end, the selective notification mailing list included 2,000 journals and news media.

Dissemination of technical information to potential users through pilot operations at regional centers continued. NASA reviewed the operations of both the established regional dissemination centers at Midwest Research Institute and Indiana University and the newer activities at Wayne State University (Detroit), the University of Pittsburgh, the University of Maryland, and the North Carolina Science and Technology Research Center. The purpose of these reviews was to determine which operating practices were most effective. Interchange of information between dissemination centers regarding certain successful operating practices was encouraged.

# Appendix A

## CONGRESSIONAL COMMITTEES ON AERONAUTICS AND SPACE

(July 1-Dec. 31, 1964)

## Senate Committee on Aeronautical and Space Sciences

CLINTON P. ANDERSON, New Mexico.

Chairman

RICHARD B. RUSSELL, Georgia

WARREN G. MAGNUSON, Washington

STUART SYMINGTON, Missouri

JOHN STENNIS, Mississippi

STEPHEN M. YOUNG, Ohio

THOMAS J. DODD, Connecticut

HOWARD W. CANNON, Nevada
SPESSARD L. HOLLAND, Florida
J. HOWARD EDMONDSON, Oklahoma
MARGARET CHASE SMITH, Maine
CLFFORD P. CASE, New Jersey
BOURKE B. HICKENLOOPER, IOWA
CABL T. CURTIS, Nebraska
KENNETH B. KEATING, New York

## House Committee on Science and Astronautics

GEORGE P. MILLER, California. Chairman OLIN E. TEAGUE, Texas JOSEPH E. KARTH. Minnesota KEN HECHLER, West Virginia EMILIO Q. DADDARIO, Connecticut J. EDWARD ROUSH, Indiana THOMAS G. MORRIS, New Mexico BOB CASEY, Texas WILLIAM J. RANDALL, Missouri JOHN W. DAVIS, Georgia WILLIAM F. RYAN, New York THOMAS N. DOWNING, Virginia JOE D. WAGGONNER, JR., Louisiana EDWARD J. PATTEN, New Jersey RICHARD H. FULTON. Tennessee Don Fuqua, Florida

NEIL STAEBLER. Michigan CARL ALBERT, Oklahoma JOSEPH W. MARTIN, JR., Massachusetts JAMES G. FULTON, Pennsylvania J. EDGAR CHENOWETH, Colorado WILLIAM K. VAN PELT, Wisconsin R. WALTER RIEHLMAN, New York CHARLES A. MOSHER, Ohio RICHARD L. ROUDEBUSH, Indiana ALPHONZO BELL, California THOMAS M. PELLY, Washington DONALD RUMSFELD, Illinois JAMES D. WEAVER, Pennsylvania EDWARD J. GURNEY, Florida JOHN W. WYDLER, New York

# NATIONAL AERONAUTICS AND SPACE COUNCIL

(July 1-Dec. 31, 1964)

(Vacant) Chairman

Vice President of the United States

Dean Rusk Secretary of State

ROBERT S. McNamara Secretary of Defense

James E. Webb, Administrator National Aeronautics and Space Administration

> GLENN T. SEABORG, Chairman Atomic Energy Commission

> > Executive Secretary
> > EDWARD C. WELSH

# Appendix C

## NASA-DOD Aeronautics and Astronautics Coordinating Board and Panels

(Dec. 31, 1964)

#### Cochairmen

Dr. Robert C. Seamans, Jr., Associate Administrator, NASA

Dr. HAROLD Brown, Director of Defense Research and Engineering, DOD

Secretaries: Mr. Richard J. Green, NASA; Mr. Albert Weinstein, DDR&E, DOD

#### Members at Large

Adm. W. F. Boone, USN (Ret.), Deputy Associate Administrator for Defense Affairs, NASA

Mr. DEMARQUIS D. WYATT, Deputy Associate Administrator for Programing, NASA

Dr. Homer E. Newell, Associate Administrator for Space Science and Applications, NASA

Dr. Albert C. Hall, Deputy Director (Space), DDR&E, DOD

Dr. ALEXANDER H. FLAX, Assistant Secretary of the Air Force (R&D), DOD Dr. EUGENE G. FURINI. Assistant Secretary of Defense/Deputy Director (Re-

Dr. EUGENE G. FUBINI, Assistant Secretary of Defense/Deputy Director (Research and Engineering), DOD

#### Aeronautics Panel

Chairman: Rear Adm. Noel A. M. Gayler, USN, Director, Development Programs Division, Office of Chief of Naval Operations, DOD

Vice Chairman: Mr. Charles W. Harper, Office of Associate Administrator for Advanced Research and Technology, NASA

#### Members

Dr. FLOYD THOMPSON, Langley Research Center, NASA

Mr. Mark R. Nichols, Langley Research Center, NASA

Mr. Woodrow L. Cook, Ames Research Center, NASA

Mr. CHARLES H. CHRISTENSON, Office of Deputy Chief of Staff, Research and Development, DOD

Mr. T. C. Muse, Office of Defense Research and Engineering, DOD

Col. A. J. RANKIN, USA, Office Chief of Research and Development, DA, DOD Secretaries: Mr. Jack D. Brewer, Office of Associate Administrator for Advanced Research and Technology, NASA; Mr. CLEM WEISMAN, DOD

Alternate: Lt. Col. J. W. KRITZAR, USAF, Office of Deputy Chief of Staff, Research and Development, DOD

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#### Launch Vehicle Panel

Chairman: Dr. Alexander H. Flax, Assistant Secretary of the Air Force (R&D), DOD

Vice Chairman: Mr. Milton W. Rosen, Office of Deputy Associate Administrator for Defense Affairs, NASA

#### Members

Mr. Edward Z. Gray, Office of the Associate Administrator for Manned Space Flight, NASA

Mr. VINCENT L. JOHNSON, Office of Associate Administrator for Space Science and Applications, NASA

Mr. John L. Sloop, Office of Associate Administrator for Advanced Research & Technology, NASA

Capt. C. C. Andrews, USN, Bureau of Naval Weapons, DOD

Col. Rodney Nudenberg, USAF, Office of Deputy Chief of Staff, Research and Development (SCRB), DOD

Mr. Heinrich J. Weigand, DCS Systems Logistics, AFSDC-A, DOD

Secretaries: Maj. Romain C. Fruge, USAF, DOD; Mr. Alfred Nelson, Office of Deputy Associate Administrator for Programing

Alternates: Mr. A. O. Tischler, Office of Associate Administrator for Advanced Research and Technology, NASA; Mr. Joe Jones, Office of the Assistant Secretary of the Air Force (R&D), DOD

#### Manned Space Flight Panel

Chairman: Dr. George E. Mueller, Associate Administrator for Manned Space Flight, NASA

Vice Chairman: Dr. Alexander H. Flax, Assistant Secretary of the Air Force (R&D), DOD

#### Members

Dr. George M. Knauf, Office of Associate Administrator for Manned Space Flight. NASA

Brig. Gen. DAVID M. JONES, USAF, Office of Associate Administrator for Manned Space Flight, NASA

Mr. Edward Z. Gray, Office of Associate Administrator for Manned Space Flight, NASA

Maj. Gen. O. J. RITLAND, USAF, Dep. Cmdr. for Space, AFSC, DOD

Capt. E. L. Anderson, USN, Office, Chief of Naval Operations, DOD

Maj. Gen. RICHARD D. CURTIN, USAF, Director of Development Plans, DOD

Secretaries: Lt. Col. RICHARD DENNEN, Office of the Assistant Secretary of the Air Force (R&D), DOD; Mr. PAUL E. COTTON, Office of the Associate Administrator for Manned Space Flight, NASA

Alternates: Mr. John H. Disher, Office of Associate Administrator for Manned Space Flight, NASA; Mr. Franklin J. Ross, Office of the Assistant Secretary of the Air Force (R&D), DOD

#### Space Flight Ground Environment Panel

Chairman: Col. CLIFFORD J. KRONAUER, USAF, Asst. Director (Ranges & Space Ground Support), ODDR&E, DOD

Vice Chairman: Mr. Edmond C. Buckley, Director, Tracking and Data Acquisition, NASA

#### Members

Mr. GERALD M. TRUSZYNSKI, Office of Tracking and Data Acquisition, NASA

Mr. John T. Mengel, Goddard Space Flight Center, NASA

Capt. John Holcomb, USN. Office of Associate Administrator for Manned Space Flight, NASA

Capt. W. G. Stearns, USN, Office of Chief of Naval Operations, DOD

Lt. Col. Jesse A. Fields, USA, Chief, Range Branch, OCRD, DOD

Col. Paul C. Murphy, Chief, Range and Facilities Division, DAF, DOD

Secretaries: Lt. Col. V. W. HAMMOND, USAF, ODDR&E, DOD; Mr. FREDERICK BRYANT, Office of Tracking and Data Acquisition, NASA

Alternates: Mr. H. R. Brockett, Office of Tracking and Data Acquisition, NASA; Col. James B. Tapp, USAF, Office, Deputy Chief of Staff, Research and Development, DOD

#### Supporting Space Research and Technology Panel

Chairman: Dr. RAYMOND L. BISPLINGHOFF, Associate Administrator for Advanced Research and Technology, NASA

Vice Chairman: Dr. Chalmers W. Sherwin, Deputy Director (Research & Technology) ODDR&E, DOD

#### Members

Mr. Milton B. Ames, Jr., Office of Associate Administrator for Advanced Research and Technology, NASA

Mr. WILLIAM H. WOODWARD, Office of Associate Administrator for Advanced Research and Technology, NASA

Dr. Walton L. Jones (Acting), Office of Associate Administrator for Advanced Research and Technology, NASA

Mr. Frank J. Sullivan (Acting), Office of Associate Administrator for Advanced Research and Technology, NASA

Capt. W. E. Berg, USN, Office of Naval Research, DOD

Brig. Gen. Edward B. Giller, USAF, Director of Science and Technology, DOD Dr. Guilford G. Quarles, Office Chief of Engineers, DOD

Secretaries: Col. John P. Taylor, USAF, IDDR&E, DOD

Mr. Reece Hensley, Office of Associate Administrator for Advanced Research and Technology, NASA

Alternate: None desired

#### Unmanned Spacecraft Panel

Chairman: Mr. Robert F. Garbarini, Director of Engineering, Office of Associate Administrator for Space Science and Applications, NASA

Vice Chairman: Mr. Starr J. Colby, Assistant Director (Space Technology), DDR&E, DOD

#### Members

Dr. John E. Naugle, Office of Associate Administrator for Space Science & Applications, NASA

Mr. Leonard Jaffe, Office of Associate Administrator for Space Science & Applications, NASA

Mr. Oran Nicks, Office of Associate Administrator for Space Science & Applications, NASA

Col. Francis J. Pallister, USA, Office, Chief of Research & Development, DA, DOD

- Capt. C. C. Andrews, USN, Astronautics Programs Officer, Bureau of Naval Weapons, Navy Depot, DOD
- Col. CHESTER J. BUTCHER, USAF, Office Deputy Chief of Staff/Research & Technology, DOD
- Secretaries: Lt. Col. Lew Allen, Jr., DDR&E, DOD; Mr. Jack Posner, Office of Associate Administrator for Space Science and Applications, NASA
- Alternates: Mr. E. O. Pearson, Office of Associate Administrator for Advanced Research & Technology, NASA; Brig. Gen. Edward B. Giller, USAF, Director of Science and Technology, DOD

# Appendix D

## NASA's Space Science Steering Committee and Subcommittees

(Dec. 31, 1964)

SPACE SCIENCE STEERING COMMITTEE

Chairman: John F. Clark Secretary: Margaret B. Beach

#### Members

EDGAR M. CORTRIGHT
WILLIS B. FOSTER
ROBERT F. GARBARINI
BENNY B. HALL
LEONARD JAFFE
URNER LIDDEL

JESSE L. MITCHELL JOHN E. NAUGLE HOMER E. NEWELL ORAN W. NICKS ORR E. REYNOLDS MORRIS TEPPER

#### ASTRONOMY SUBCOMMITTEE

Chairman: NANCY G. ROMAN Secretary: ERNEST J. OTT

#### Members

ALASTAIR G. CAMERON, Goddard Space Flight Center ARTHUR DODD CODE, University of Wisconsin ROBERT F. FELLOWS, NASA
DAVID FISCHEL, Ames Research Center
KENNETH L. HALLAM, Goddard Space Flight Center
WILLIAM MARKOWITZ, U.S. Naval Observatory
NICHOLAS U. MAYALL, Kitt Peak National Observatory
GUIDO MUNCH, Mt. Wilson and Palomar Observatory
LEONARD ROBERTS, Langley Research Center
EDWIN ERNEST SALPETER, Cornell University
CHARLES L. SEEGER, University of Texas
HARLAN J. SMITH, University of Texas
HENRY J. SMITH, NASA
ROY C. STOKES, Manned Spacecraft Center
ROBERT G. STONE, Goddard Space Flight Center

BIOSCIENCE SUBCOMMITTEE Chairman: ORR E. REYNOLDS Secretary: VIRGINIA B. BOLTON

#### Members

ALLAN H. BROWN, University of Pennsylvania LOREN D. CARLSON, University of Kentucky SIDNEY FOX, University of Miami JOHN DOUGLAS FRENCH, University of California SIDNEY R. GALLER, Office of Naval Research JAMES P. HENRY, University of California GEORGE L. HOBBY, Jet Propulsion Laboratory HAROLD P. KLEIN, Ames Research Center ELLIOTT LEVINTHAL, Stanford University
URNER LIDDEL, NASA
GERALD M. McDonnel, University of California
ERNEST C. POLLARD, Penn State University
CARL SAGAN, Harvard University
JAMES NEWELL STANNARD, University of Rochester
WILLIAM C. STROUD, Goddard Space Flight Center
HANS-LUKAS TEUEER, Massachusetts Institute of Technology

#### IONOSPHERES AND RADIO PHYSICS SUBCOMMITTEE

Chairman: ERWIN R. SCHMERLING Secretary: RAYMOND MILLER

#### Members

ROBERT E. BOURDEAU, Goddard Space Flight Center
ROGER GALLET, National Bureau of Standards
OWEN K. GARRIOTT, Stanford University
WILLIAM B. HANSON, Graduate Research Center of the Southwest
COLIN O. HINES, University of Chicago
JOHN E. JACKSON, Goddard Space Flight Center
CHARLES Y. JOHNSON, Naval Research Laboratory
EUGENE A. MECHTLY, Marshall Space Flight Center
MILLETT GRANGER MORGAN, Dartmouth College
THOMAS EDWARD VAN ZANDT, National Bureau of Standards

#### PARTICLES AND FIELDS SUBCOMMITTEE

Chairman: Alois W. Schardt Secretary: Albert G. Opp

#### Members

HERBERT SAGE BRIDGE, Massachusetts Institute of Technology
LAURENCE J. CAHILL, Jr., University of New Hampshire
LEVERETT DAVIS, Jr., California Institute of Technology
WILMOT N. HESS, Goddard Space Flight Center
KENNETH GORDON McCracken, Graduate Research Center of the Southwest
Frank B. McDonald, Goddard Space Flight Center
CARL EDWIN McIlwain, University of California
NOBMAN F. NESS, Goddard Space Flight Center
EUGENE N. PARKER, University of Chicago
JOHN ALEXANDER SIMPSON, University of Chicago
CONWAY W. SNYDER, Jet Propulsion Laboratory
CHARLES P. SONETT, Ames Research Center
WILLIAM R. WEBBER, University of Minnesota
JOHN H. WOLFE, Ames Research Center.

#### PLANETARY ATMOSPHERES SUBCOMMITTEE

Chairman: ROBERT F. FELLOWS Secretary: HAROLD F. HIPSHER

#### Members

SIEGFRIED J. BAUER, Goddard Space Flight Center TALBOT A. CHUBB, Naval Research Laboratory FRANK B. GRAY, Jet Propulsion Laboratory

775-519 O-65---14

HANS E. HINTEREGGER, Air Force Cambridge Research Laboratory
Donald M. Hunten, Kitt Peak National Observatory
Edward C. Y. Inn, Ames Research Center
Francis S. Johnson, Southwest Center for Advanced Studies
William W. Kellogg, National Center for Atmospheric Research
Charles Gordon Little, National Bureau of Standards
Alfred O. C. Nieb, University of Minnesota
Andrew E. Potter, Lewis Research Center
Nelson W. Spencer, Goddard Space Flight Center

#### PLANETOLOGY SUBCOMMITTEE

Chairman: URNER LIDDEL Secretary: RICHARD J. ALLENBY

#### Members

CHARLES L. CRITCHFIELD, University of California GEORGE B. FIELD, Princeton University Observatory CLARK D. GOODMAN, University of Houston JOHN SCOVILLE HALL, Lowell Observatory HABRY HAMMOND HESS, Princeton University GORDON J. F. MACDONALD, University of California ROBERT MEGHREBLIAN, Jet Propulsion Laboratory JOHN A. O'KEEFE, Goddard Space Flight Center HAROLD C. UREY, University of California DONALD U. WISE, Franklin and Marshall College

#### SOLAR PHYSICS SUBCOMMITTEE

Chairman: Henry J. Smith Secretary: Richard E. Halpern

#### Members

RUSSELL GRANT ATHAY, High Altitude Observatory
MICHEL BADER, Ames Research Center
ROBERT DANIELSON, Princeton University
MAURICE DUBIN, NASA
WILLIAM ERICKSON, University of Maryland
JOHN WAINWRIGHT EVANS, Jr., Sacramento Peak Observatory
HERBERT FRIEDMAN, Naval Research Laboratory
LEO GOLDBERG, Harvard College Observatory
WILLIAM L. KRAUSHAAR, Massachusetts Institute of Technology
JOHN C. LINDSAY, Goddard Space Flight Center
ALAN MAXWELL, Harvard Radio Astronomy Station
LAURENCE E. PETERSON, University of California
WALTER ORR ROBERTS, National Center for Atmospheric Research
NANCY G. ROMAN, NASA

# Appendix E

# NASA's Industrial Applications Advisory Committee

(Dec. 31, 1964)

Acting Chairman: Breene M. Kerr, Assistant Administrator for Technology Utilization

#### Members

JAMES HILLER, Vice President, RCA Laboratories, Princeton, N.J.

MALCOLM M. HUBBARD, Hubbard Associates, Newton, Mass.

Dr. Augustus B. Kinzel, Vice President, Research, Union Carbide Corp., New York, N.Y.

EARL P. STEVENSON, Arthur D. Little, Inc., Cambridge, Mass.

Dr. Howard S. Turner, Vice President, Research and Development, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

ALTON D. ANDERSON, Vice President and General Manager, Tech-Center Division, Cook Technological Center, Morton Grove, Ill.

Acting Executive Secretary: Charles F. Yost, Director, Technology Utilization Division, NASA Headquarters.

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# Appendix F

## NASA's Major Contractors 1

(July 1-December 31, 1964)

Bellcom, Inc., Washington, D.C. Bendix Corp.,2 Teterboro, N.J. Boeing Co., New Orleans, La. Brown Engineering Co., Huntsville, Ala. Catalytic Construction Co.,2 Merritt Island, Fla. Chrysler Corp.,2 New Orleans, La. Collins Radio Co.,2 Richardson, Tex. Douglas Aircraft Co., Inc., Santa Monica, Calif. General Dynamics Corp., 2 San Diego, Calif. General Electric Co., Huntsville, Ala. General Motors Corp.,2 Milwaukee, Wis. Grumman Aircraft Engineering Corp., Bethpage, N.Y. Hayes International Corp., Birmingham, Ala. Hughes Aircraft Co.,2 Culver City, Calif. International Business Machines, Oswego, N.Y. Lear Siegler, Inc.,2 Anaheim, Calif. Lockheed Aircraft Corp., Sunnyvale, Calif. McDonnell Aircraft Corp., St. Louis, Mo. North American Aviation, Inc., Downey, Calif. Philco Corp., Houston, Tex. Radio Corporation of America,2 Van Nuys, Calif.

Aerojet-General Corp., Sacramento, Calif.

Thompson Ramo Wooldridge, Inc., 2 Redondo Beach, Calif.

United Aircraft Corp..2 West Palm Beach, Fla.

Sperry Rand Corp., Houston, Tex.

<sup>&</sup>lt;sup>1</sup>A list of 100 business firms giving the net value of NASA's direct awards, percentage of total awards to business, and the rank of these contractors during July-December 1963 as compared to July-December 1964 is included in Annual and Semiannual Procurement Reports available from the Special Inquiries and Reports Division (Code KDG), Procurement Office, National Aeronautics and Space Administration, Washington, D.C., 20546.

<sup>&</sup>lt;sup>2</sup> Awards during period involve more than one contractor address.

# Appendix G

# Current Official Mailing Addresses for Field Installations

(Dec. 31, 1964)

Installation and telephone number	Official	Address
Ames Research Center; 805-Y08-9411.	Dr. Smith J. DeFrance, Director_	Moffett Field, Calif., 94035.
Electronics Research Center; 617-491-1500.	Dr. Winston E. Kock, Director	575 Technology Square, Cam- bridge, Mass., 02139.
Flight Research Center; 805-258-3311_	Mr. Paul Bikle, Director	Post Office Box 273, Edwards, Calif., 93523.
Goddard Space Flight Center; 301-474-9000.	Dr. H. J. Goett, Director	Greenbelt, Md., 20771.
Goddard Institute for Space Studies; 212-UN6-3600.	Dr. Robert Jastrow, Director	475 Riverside Drive, New York, N.Y., 10027.
Jet Propulsion Laboratory; 213- SY0-6811.	Dr. W. H. Pickering, Director	4800 Oak Grove Drive, Pasa- dena, Calif., 91103.
John F. Kennedy Space Center; 305– UL3-6998.	Dr. Kurt Debus, Director	Cocoa Beach, Fla., 32931.
Langley Research Center; 703-722-7961.	Dr. Floyd L. Thompson, Director.	Langley Station, Hampton, Va., 23365.
Lewis Research Center; 216-433-4000.	Dr. Abe Silverstein, Director	21000 Brookpark Road, Cleve- land, Ohio, 44135.
Manned Spacecraft Center; 713- WA8-2811.	Dr. R. R. Gilruth, Director	Houston, Tex., 77058.
George C. Marshall Space Flight Center; 205-877-1000.	Dr. Wernher von Braun, Director.	Huntsville, Ala., 35812.
Michoud Operations; 504-521-3311	Mr. George Constan, Manager	Post Office Box 26078, New Orleans, La., 70126.
Mississippi Test Operations; 601–467–5466.	Mr. William C. Fortune, Manager	Bay St. Louis, Miss., 39520.
Pacific Launch Operations Office; 805-RE4-4311.	Mr. William H. Evans, Director	Post Office Box 425, Lompac, Calif., 93438.
Plum Brook Station; 419-MA5-1123	Mr. Alan D. Johnson, Director	Sandusky, Ohio, 44871.
Wallops Station; 703-VA4-3411	Mr. Robert Krieger, Director	Wallops Island, Va., 23337.
Western Operations Office; 213-EX3- 9641.	Mr. R. W. Kamm, Director	150 Pico Blvd., Santa Monica, Calif., 90406.

# Appendix H

# Principal NASA Officials at Washington Headquarters

(Dec. 31, 1964)

James E. Webb	Administrator.
Dr. Hugh L. Dryden	Deputy Administrator.
Dr. George L. Simpson, Jr	Assistant Deputy Administrator, and As-
	sistant Administrator, Office of Technol-
	ogy Utilization and Policy Planning.
Walter D. Sohier	General Counsel.
Arnold W. Frutkin	Assistant Administrator, Office of Inter-
	national Affairs.
Richard L. Callaghan	Assistant Administrator, Office of Legisla-
-	tive Affairs.
Julian Scheer	Assistant Administrator, Office of Public
	Affairs.
Dr. Robert C. Seamans, Jr	Associate Administrator.
Earl D. Hilburn	
	Deputy Associate Administrator, Office of
5	Administration.
George Friedl, Jr	Deputy Associate Administrator, Office of
,	Industry Affairs.
DeMarquis D. Wyatt	Deputy Associate Administrator, Office of
-	Programing.
Adm. W. Fred Boone, USN (Ret.)	Deputy Associate Administrator, Office of
, , , , , , , , , , , , , , , , , , , ,	Defense Affairs.
Edmond C. Buckley	Director, Office of Tracking and Data
•	Acquisition.
Dr. Raymond L. Bisplinghoff	Associate Administrator, Office of Advanced
•	Research and Technology.
Dr. George E. Mueller	Associate Administrator, Office of Manned
	Space Flight.
Dr. Homer E. Newell	Associate Administrator, Office of Space
	Science and Applications.
(Telephone Information: WO 3-710	
	•
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# Appendix 1

# Membership of Inventions and Contributions Board, NASA

# (Dec. 31, 1964)

Chairman	. ROBERT E. LITTELL
Vice Chairman	
Executive Secretary	JAMES A. HOOTMAN
Members	
	C. GUY FERGUSON
	GERALD D. O'BRIEN
	JOHN B. PARKINSON
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# Appendix J

# Patent Waivers Recommended for Grant or Denial by the Agency's Inventions and Contributions Board

(July 1-Dec. 31, 1964)

Invention	Petitioner	Board Rec ommenda- tion
Quick Disconnect Mechanism	North American Aviation, Inc	Grant.
Radiation Monitoring Apparatus	Republic Aviation Corp	Do.
Modulated Power Supply	Collins Radio Co	Denial.
In Line Multiple Circuit Protector	McDonnell Aircraft Corp	Grant.
Iterative Division System.	International Business Machines Corp.	Do.
Improvements in Propellant Grain for Rocket Motor.	Lockheed Propulsion Co	Denial.
$ \begin{array}{lll} \textbf{Coating} & \textbf{Made} & \textbf{from} & \textbf{Bis}(\textbf{Methylamino}) \textbf{Diphen-ylsilane}. \end{array} $	Southern Research Institute	Grant.
Method of Making Polymeric Diphenylsilane.	do	Do.
Elastomer Made From Methylphenyl Silazane and Ethylenediamine Silazane.	do	Do.
Hypervelocity Gun	MB Associates	
Spacecraft Cabin Facilities		Denial.
Infrared Acquisition Aid for a Tracking System		Grant.
Magnetic Recorder		
Current Steering Using Multiple Aperature Device.	Stanford Research Institute	1
A Gear Crank Pivot Assembly for Operating a Mechanical Seal Face-Piece on High Altitude Flying and Space Suits.	The B. F. Goodrich Co	Do.
Treatment for Glass to Reduce Helium Permeation	Midwest Research Institute	Do.
Device for Separating a Liquid from A Gas	Midland-Ross Corp	Do.
Shear-Plate Mirror Light Beam Deflector	Laboratories.	Do.
Electro-Optic Light Beam Refractor		1
Segmented Manifold		
Torsion Bar Seal Follow-Up		
Control System for Fuel Cells		
Fuel Cell Floating Elements	do	Do.
Self-Regulating Liquid Removal System		
Treatment for Magnetron Gauges to Cause Improved & Uniform Response.	Midwest Research Institute	1
An Omni-Directional Receiving System Application of Ceramic Paper to the Construction of	Franklin Institute	1
Traps for Vacuum Systems.	University of Illinois	
Divergent Injector	North American Aviation, Inc	1
Re-entry Corridor Indicator	do	
Process for the Synthesis of L. S. Different by Land	Peninsular Chem Research, Inc	
Process for the Synthesis of 1, 2-Diffuoroethylene Energy Absorbing Device	Accorded Brown Accorded	
Use of Ion Exchange Membranes in Nonaqueous		
Primary Batteries.  A Method of Evaluating the Energy Denstiy Capa-	Livingston Electronic Corpdodo	
bilities of Electrolytes for Use in Primary Batteries.		

Invention	Petitioner	Board Recommenda- tion
Use of Coordination Compounds, Complex Ions, and Penetration Complexes as Conducting Species in Aprotic, Protic and other Types of Nonaqueous Primary Batteries.	do	Do.
Process for the Synthesis of Perfluoro (Methyl vinyl ether) CF <sub>2</sub> OCF=CF <sub>2</sub> .	Peninsular ChemResearch, Inc	Do.
Conical Hydrostatic Floating Bearing.	Aerojet-General Corp	Do.
Hollow Filament Forms for Winding Composite Structures.	DeBell and Richardson, Inc	Do.
Solid Filament Forms for Winding to Form Wound Composite Structures.	do	Do.
Turbopump Arrangement	United Aircraft Corp	Denial.
Folding Structure Fabricated of Rigid Panels		Grant.

# Appendix K

# Patent Waivers Granted and Denied by NASA Upon Recommendation of the Agency's Inventions and Contributions Board

(July 1-Dec. 31, 1964)

Invention	Petitioner	Action on petition
Transistorized Ring Counter Circuit		Granted July 23, 1964
Solder Valve	TRW Space Technology Labora- tories, Inc.	Granted July 21, 1964
Chassis Unit Insert Tightening-Extract Device.	Collins Radio Co	Do.
Low Heat Piping Connection	Air Products & Chemicals Inc	Do.
Opto-Mechanical Color Modulator	University of California	Do.
Dry Tape Fuel Cell.	Monsanto Research Corp	Do.
High Temperature Protective Coatings	Fenwal, Inc	Granted July 23, 1964.
Adjustable Clamp	Vitro Corporation of America	Granted July 21, 1964.
Control Apparatus for Signal Generating System.	Hazeltine Corp	Granted Sept. 17, 1964.
Electronic Light Polarization Analyzer	W. R. Moss	Do.
Static Moisture Removal System for the Hydrogen-Oxygen Fuel Cell.	Allis-Chalmers Manufacturing Co	Do.
Three Position Positive Centering Rocker Switch Actuator.	North American Aviation, Inc	Granted Nov. 2, 1964
Rear Projection Screen and Method of Making the Screen.	International Electric Corp	Granted Sept. 17, 1964
Sinusoidal Pressure Generator for Dy- namic Calibration and Testing of Pres- sure Transducers.	Princeton University	Do.
Small Passage Device for Transient Pressure Measurements.	Princeton University	Do.
Attitude Control System for Spin Stabilized Sounding Rockets.	Aerojet-General Corp	Denied Oct. 5, 1964.
Hydrazine Decomposition and Other Reactions.	Shell Development Co	Granted Nov. 2, 1964
Precision Linear Actuator	Kollsman Instrument Corp	Granted Nov. 3, 1964
Analog Computer for Calculation of Cardiac Output.	Kaman Aircraft	Do.
Fluid Amplifier Shaping Networks	General Electric Co	Granted Oct. 5, 1964
Pneumatic Position Control Systems	General Electric Co	Do.
Incremental Fluid Flow Control Device	Curtiss-Wright Corp	Granted Nov. 3, 1964
Process for Removal of Adhesive From Polyolefin Film—Metal Foil Laminates in an Area Not Covered by Metal Foil.	G. T. Schjeldahl Co	Granted Nov. 23, 1964
Logically Redundant Flip-Flop	Kollsman Instrument Corp	Granted Dec. 2, 1964
Wabble Gear Drive Mechanism	TRW Space Technology Labora- tories, Inc.	Do.
Coatings made with Hexaphenylcyclotri- silazane By-Product.	Southern Research Institute	Do.
Vacuum Gage	National Research Corp	Granted Dec. 17, 1964
Thermal Interface Material	North American Aviation, Inc	
Superconductive Thin Films		

# Appendix L

# Scientific and Technical Contributions Recognized by the Agency's Inventions and Contributions Board

(July 1-Dec. 31, 1964)

# Awards Granted Under Provisions of Section 306 of the Space Act of 1958

Contribution	Inventor(s)	Employer
Low Speed Time Multiplexing.	John F. Meyer	Jet Propulsion Laboratory.
Sensing Devices	Gerald W. Meisenholder, James D. Acord, Howard C. Vivian, and Louis F. Schmidt.	Do.
Commercial Air Transport	Adrien E. Anderson, Woodrow L. Cook, James C. Daugherty, J. Lloyd Jones, Jr., and David G. Koenig.	Ames Research Center.
Flight Craft	Alfred J. Eggers, Jr., Clarence A. Syvert- son, George G. Edwards, and George C. Kenyon.	Do.

# Appendix M

# Awards Granted NASA Employees Under Provisions of the Incentive Awards Act of 1954

(July 1-Dec. 31, 1964)

Contribution	Inventor(s)	Employer
Method for Continuous Variation of Propellant Flow and Thrust.	Gerald Morrell	Lewis Research Center.
Particle Beam Power Density Probe.	Lionel V. Baldwin and Virgil A. Sandborn.	Do.
Instantaneous Diffusion Bonded Plasma Spray Coating.	Salvatore Grisaffe and William A. Spitzig.	Do.
Regenerative Molton Salt Fuel Cell.	Jacob Greenberg and Lawrence H. Thaller.	Do.
Milling Apparatus	Max H. Sharpe	Marshall SFC.
Radial Module Space Station	Owen E. Maynard, Williard Taub, David Brown, Edward H. Olling, and Robert M. Mason.	Manned Spacecraft Center.
Shock Absorbing Support and Restraint Means.	Douglas J. Geier, Richard S. Johnston, Gerard J. Pesman, and Matthew I. Radnofsky.	Do.
Alleviation of Divergence During Rocket Launch.	Warren Gillespie, Jr	Do.
Molecular Beam Velocity Selector.	Robert Steinberg	Lewis Research Center.
Device for Directionally Control- ling Electromagnetic radiation.	Morris Perlmutter and John R. Howell.	Do.
A Colloid Propulsion Method and Apparatus.	Carl T. Norgren	Do.
Sun Tracker	Frank A. Volpe and Benjamin G. Zimmerman.	Goddard SFC.
Diversity Locked Combining System.	Vincent J. DiLosa and Charles R. Laughlin, Jr.	Do.
Quick Attach and Release Fluid Coupling Assembly.	Curt P. Herold and Sam D. Stahley.	JFK Space Center.
Reversible Ring Counter	John N. Libby and Harry D. Moore.	Goddard SFC.
Interconnection of Solar Cells	Joseph G. Haynos	Do.
Continuously Operating Induc- tion Plasma Accelerator.	Raymond L. Barger, Joseph D. Brooks, and William D. Beasley.	Langley Research Center.
Micro-Particle Impact Sensing Apparatus.	Otto E. Berg and W. Merle Alexander	Goddard SFC.
An Optical Torquemeter	Donald R. Buchele, Alois Kreck, Jr., and Marvin W. Tiefermann.	Lewis Research Center.
Transducer and Method of Using the Same.	Vernon L. Rogallo	Ames Research Center.
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# Appendix N

### Educational Publications and Motion Pictures

(Dec. 31, 1964)

The following educational publications are available to the public without charge from the Office of Educational Programs and Services, Educational Publications Distribution Center, Code AFEE-1, National Aeronautics and Space Administration, Washington, D.C., 20546.

#### Booklets and Folders

- Space, the New Frontier.—An illustrated booklet introducing the reader to space exploration and the programs of the National Aeronautics and Space Administration. 76 pages.
- X-15, Aircraft Research at the Edge of Space.—A 15,000-word in-depth booklet on the X-15 program. 32 pages.
- Manned Space Flight Team.—A booklet of biographies and pictures of the astronauts and astronaut trainees and their training programs. 16 pages.
- America in Space.—A pictorial review of the 5 years of space exploration following establishment of NASA. 72 pages.
- NASA Photography from Five Years of Space.—A booklet of 96 photographs that show highlights in manned space flight, space sciences, applications, and advanced research and technology, during NASA's first 5 years of activity. 36 pages.
- Unmanned Spacecraft of the United States.—Edgar M. Cortright, NASA's Deputy Associate Administrator for Space Science and Applications, describes past, present, and future scientific space programs in which unmanned instrumented spacecraft are sent into earth orbit and beyond. 16 pages.
- Medical Aspects of Space Flight.—Frank B. Voris, M.D., Chief of NASA's Human Research Branch, discusses some of the major space medicine problems related to future prolonged manned space flight and exploration missions. 16 pages.
- Advanced Research, Key to the Future.—In-depth but popular-language description of NASA's research program. Among the topics covered are aircraft operating problems, launch vehicle and spacecraft dynamics, materials and structures, hypersonic flight, magnetoplasmadynamics, man in a space environment, manned space flight simulation, research in low speed flight, and supersonic aircraft research. 44 pages.
- TIROS, the First Weather Satellite.—Captioned photographs and a page of text about the "weather eye" satellites. 9 pages.
- Educational Services.—A folder that discusses briefly the NASA services and programs available for teachers and students. 12 pages.

- Teaching To Meet the Challenge of the Space Age.—Information for elementary teachers to assist them in presenting aerospace facts and concepts. 32 pages.
- Ranger VII, a Special Report.—Describes the mission and results of the Ranger experiment which provided mankind with the first close-up pictures of the moon's surface. 35 pages.
- What Makes a Rocket Go?—A teacher's film guide for use with the motion picture of the same title. 8 pages.

#### NASA Facts

Describe NASA programs, with photographs and diagrams of spacecraft and launch vehicles. Sheets are designed for bulletin board display or for insertion in looseleaf notebooks.

- Orbiting Solar Observatory.—Investigation of solar radiation. 8 pages.
- Ariel, First International Satellite.—The United Kingdom-United States satellite for study of the ionosphere and of cosmic radiation. 4 pages.
- Mariner.—A United States spacecraft for study of interplanetary space and for relaying data on the atmosphere and temperature of Venus. 8 pages.
- Mariner II Reports.—A comprehensive summary of the Mariner II findings about the planet Venus and about interplanetary space between the Earth and Venus. 8 pages.
- The Explorer Satellites.—Geophysical satellites for study of the earth environment and upper atmosphere surrounding the earth, including such phenomena as radiation fields, cosmic rays, micrometeroids, temperature, magnetic fields, solar radiation, air density, solar plasma, and gamma rays. 12 pages.
- Explorer XVI.—The micrometeroid satellite and its purposes. 4 pages.
- Alouette, Canada's First Satellite.—Describes a new way of studying the ionosphere by satellite. 6 pages.
- Relay.—The Relay experiment in medium-altitude active repeater communications satellites. 9 pages.
- Syncom.—The Syncom experiment in synchronous orbit communications satellites. 8 pages.
- TIROS.—The satellite whose TV cameras observe the earth's cloud cover from above. 8 pages.
- Interplanetary Explorer Satellites.—A discussion in depth of Explorer XVIII, the first interplanetary Explorer, which is gathering data on radiation and magnetic fields in space between the earth and the moon. 8 pages.
- Explorer XIX.—A description of Explorer XIX and its goal of adding information about air densities at altitudes above 100 miles. 8 pages.
- V/STOL Aircraft.—Survey of NASA's research on aircraft that take off and land either vertically or with a relatively short runway. 12 pages.

#### **Bibliographies**

Aeronautics and Space Bibliography for Elementary Grades.—36 pages.

Aeronautics and Space Bibliography for Secondary Grades.—52 pages.

Aeronautics and Space Bibliography of Adult Aerospace Books and Materials.—44 pages.

#### Motion Pictures

During 1964 NASA released the following seven motion pictures. These are available to the public upon request without charge, other than return mailing and insurance costs, from the Office of Educational Programs and Services, Code AFEE, National Aeronautics and Space Administration, Washington, D.C., 20546. (Other films are listed in a brochure supplied from the same address.)

- Ariel II.—26½ min., sound, color. Produced by Goddard Space Flight Center. The history of the second international satellite and how it was developed and orbited by American and United Kingdom scientists and engineers to gain new knowledge about the structure of the universe. It guides you through the research and development of the experiments in England to the assembly, testing, evaluation and launch of the spacecraft in the United States.
- Manned Space Flight 1964.—14 min., sound, color. An up-to-date movie report of NASA's manned flight programs. Describes the two-man Gemini earth-orbital and three-man Apollo lunar landing missions.
- Ranger VII Photographs of the Moon.—7 min., sound, black and white. Produced by Jet Propulsion Laboratory. Step printed TV photographs of the moon taken by the "A" camera of Ranger as it approached the lunar surface on July 31, 1964. A more detailed description of selected photographs is given at the end of the film.
- Lunar Bridgehead.—29 min., sound, black and white. Produced by Jet Propulsion Laboratory. On-the-spot coverage of events surrounding the lanuch and successful flight of Ranger VII. The spacecraft transmitted over 4,000 high-resolution photographs as it approached the lunar surface, some of these are included in the film.
- The World Was There.—29 min., sound, color. (16 and 35 mm.) How the free world news media reported the space flights of the six U.S. astronauts. Onthe-scene descriptions from the TV-radio newspool of reporters Walter Cronkite, Herbert Kaplow, Jules Bergman, Ed Williams, Ray Scherer, and many others. Main narration is by Alexander Scourby. Highlighted in the film are the difficult open sea rescues of Grissom and Carpenter and the unparalleled public response to John Glenn's flight.
- A Moment in History.—13½ min., sound, color. Produced by Goddard Space Flight Center. Events leading to the presentation of honorary U.S. citizenship to Sir Winston Churchill by President Kennedy on April 9, 1963. The live TV transmission was sent via Relay satellite from the White House to England.
- The World Beyond Zero.—28 min., sound, color. Produced by Goddard Space Flight Center. The story of a satellite and the cooperative efforts of world-wide network tracking stations linking space scientists and engineers with their orbiting spacecraft. Views of Cape Kennedy, Lima, Peru, Santiago, Chile, Johannesburg, South Africa, Anchorage, Alaska, Winkfield, England, and Woomera, Australia. Film stresses cooperation between nations in the exploration of space.

#### Appendix O

#### Technical Publications

The following selected special publications, issued by NASA's Scientific and Technical Information Division, are sold by the Superintendent of Documents, U.S. Government Printing Office (GPO), Washington, D.C., 20402, or by the Clearinghouse for Federal Scientific and Technical Information (Clearinghouse), 5285 Port Royal Road, Springfield, Va., 22151, at the prices listed.

Physics of Nonthermal Radio Sources (NASA SP-46).\*—Proceedings of a conference for an international group of astronomers and physicists, held December 3-4, 1962, at the NASA Goddard Institute for Space Studies. The papers cover radio observations, optical observations, and theory of nonthermal radio sources outside the solar system. 171 pp. GPO, 75 cents.

AAS-NASA Symposium on the Physics of Solar Flares (NASA SP-50).\*—The published proceedings of a conference of American, European, Asian, and Australian scientists reporting on research progress in the field of solar flare activity. 466 pp. GPO, \$3.25.

Proceedings of the Fourth National Conference on the Peaceful Uses of Space (NASA SP-51).\*—Thirty papers delivered at the Conference held in Boston, April 29 to May 1, 1964. Six sessions: Space and the Nation, Congress and Science, Men in Space, Machines in Space, Practical Uses of Satellites, Living in Space, and Working for Space. 226 pp. GPO, \$1.50.

Quasi-Global Presentation of TIROS III Radiation Data (NASA SP-53).\*—Explanatory text, illustrations, and colored maps of the reflected solar radiation of the earth-atmosphere system on July 16, 1961, superimposed on various synoptic analyses to study the utility of the satellite radiation data for purposes of meteorological analysis. 24 pp. GPO, \$2.

Concepts for Detection of Extraterrestrial Life (NASA SP-56).\*—The devices and instruments described in this illustrated booklet are among those planned for inclusion in vehicles designed to land on planets such as Mars. They constitute techniques for detecting growth and metabolism, for determining the presence of biologically significant molecules, and for actual visual observation of micro-organisms and the planetary terrain. 54 pp. GPO, 50 cents.

Ranger VII Photographs of the Moon. Part I: Camera "A" Series (NASA SP-61).\*—Reproduction of the 199 photographs taken by the "A" camera of Ranger VII from 1,300 miles to 3 miles altitude above the surface of the moon. 266 pp. GPO, \$6.50.

Clarity in Technical Reporting (NASA SP-7010).\*—Basic principles of technical reporting designed to guide engineers and scientists in improving the general quality of written and oral reports. 25 pp. GPO, 15 cents.

The International System of Units—Physical Constants and Conversion Factors (NASA SP-7012).\*—This document gives definition of the basic units of

<sup>\*</sup> Released during this report period.

the Systeme International, adopted officially by the 1960 Eleventh General Conference on Weights and Measures, and tables for converting from U.S. Customary Units. 20 pp. GPO, 20 cents.

Advanced Bearing Technology (NASA SP-38).—An exposition of the fundamentals of friction and wear, fluid-film bearings, and rolling-element bearings, plus demonstrations of how fundamental principles can be applied to the solution of unique and advanced bearing problems. Authors, Edmond E. Bisson and William J. Anderson, Lewis Research Center. 511 pp. GPO, \$1.75.

Selected Listing of NASA Scientific and Technical Reports for 1963 (NASA SP-7005).—A comprehensive listing, complete with abstracts and indexes, of the Agency's reports during the year. 230 pp. Clearinghouse, \$3.50.

Conference on the Law of Space and of Satellite Communications (NASA SP-44).—Proceedings of a conference organized by Northwestern University School of Law, May 1-2, 1963, as part of the Third National Conference on the Peaceful Uses of Space. 205 pp. GPO, \$1.50.

Space-Cabin Atmospheres. Part I—Oxygen Toxicity (NASA SP-47).\*—A review of the literature on toxicity of oxygen at pressures of less than 1 atmosphere and the relation of oxygen to other factors of concern in space cabins, such as radiation effects and lung blast. 51 pp. GPO, 40 cents.

Space-Cabin Atmospheres. Part II—Fire and Blast Hazards (NASA SP-48).—A summary of the open literature on the subject, intended primarily for biomedical scientists and design engineers. 119 pp. GPO, \$1.

Meteorological Observations Above 30 Kilometers (NASA SP-49).—Three papers on meteorological rockets, network data, and rocket soundings comprising one session of a conference on Meteorological Support for Aerospace Testing and Operation, July 11-12, 1963. 57 pp. GPO, 40 cents.

Project Mercury Summary Including Results of the Fourth Manned Orbital Flight, May 15 and 16, 1963 (NASA SP-45).—A review of the planning, preparation, experiences, and results of the first U.S. manned space flight program, with particular attention to the results of the final, 34-hour mission of L. Gordon Cooper. 444 pp. GPO, \$2.75.

Project Mercury—a Chronology (NASA SP-4001).—A listing of major events in the first U.S. manned space flight program from preliminary discussions of earth satellite vehicles through Astronaut Cooper's 22-orbit flight, May 1963. 238 pp. GPO, \$1.50.

Third United States Manned Orbital Space Flight (NASA SP-12).—Results of the MA-8 flight by Astronaut Walter Schirra, October 1962, including spacecraft and launch vehicle performance, mission operations, aeromedical analysis, pilot performance, and pilot's flight report. 120 pp. GPO, 70 cents.

Second United States Manned Orbital Space Flight (NASA SP-6). Results of the MA-7 flight by Astronaut M. Scott Carpenter, May 1962, including spacecraft and launch vehicle performance, Mercury network performance, mission operations, space science report, aeromedical studies, pilot performance, and pilot's flight report. 107 pp. GPO, 65 cents.

Results of the Project Mercury Ballistic and Orbital Chimpanzee Flights (NASA SP-39).—An account of the suborbital and orbital flights conducted in 1961 with chimpanzees as subjects in preparation for the first U.S. manned space flights. 71 pp. GPO, 45 cents.

Space, Science, and Urban Life (NASA SP-37).—Proceedings of a conference, March 1963, on the applicability of the national space program, and the knowledge resulting from aerospace research, to the problems of urban growth. 254 pp. GPO, \$1.75.

The Observatory Generation of Satellites (NASA SP-30).—Discussion of the missions and engineering designs of the Orbiting Geophysical Observatories, the Advanced Orbiting Solar Observatory, and the Orbiting Astronomical Observatory. 62 pp. GPO, 50 cents.

Ariel I: The First International Satellite (NASA SP-43).—Project summary of the satellite launched April 26, 1962, in a cooperative effort by the United Kingdom and the United States. 76 pp. GPO, 70 cents.

U.S. Standard Atmosphere, 1962.—Updated tables of atmospheric parameters to 700 kilometers, incorporating results of rocket and satellite research through mid-1962. 278 pp., in hard covers. GPO, \$3.50.

Short Glossary of Space Terms (NASA SP-1).—Brief definitions of technical terms frequently used by space technologists. 57 pp. GPO, 25 cents.

NASA-Industry Program Plans Conference, 1963 (NASA SP-29).—Statements describing NASA's organization, present plans, and possible future projects presented for the information of industrial management as a partner in the national space program. 231 pp. GPO, \$1.25.

Conference on Space-Age Planning (NASA SP-40).—Proceedings of the general sessions of the Third National Conference on the Peaceful Uses of Space, May 1963. 301 pp. GPO, \$2.

Proceedings of the Second National Conference on the Peaceful Uses of Space (NASA SP-8).—Principal addresses, scientific papers, and panel discussions at a conference in May 1962. 282 pp. GPO, \$1.50.

Measurement of Thermal Radiation Properties of Solids (NASA SP-31).—Proceedings of a symposium held in September 1962 and sponsored jointly by NASA, the Air Force, and the National Bureau of Standards. 587 pp. GPO, \$3.50.

Proceedings of the NASA-University Conference on the Science and Technology of Space Exploration, Chicago, Ill., November 1962 (NASA SP-11)—

Volume 1: NASA's role in space exploration; developing special skills for research in the space sciences; impact of the space program on the universities; the role of the university in meeting national goals in space exploration; radar astronomy; the sounding rocket as a tool for college and university research; geophysics and astronomy; lunar and planetary sciences; celestial mechanics and space flight analysis; data acquisition and processing; control, guidance, and navigation; bioastronautics. 429 pp. GPO, \$2.50.

Volume 2: Chemical rocket propulsion; nuclear propulsion; power for spacecraft; electric propulsion; aerodynamics; gas dynamics; plasma physics and magnetohydrodynamics; laboratory techniques; materials; structures. 532 pp. GPO, \$3.

The scientific papers presented at the conference, grouped by topics, are also available as separate state-of-the-art summaries:

	Cents
Geophysics and Astronomy in Space Exploration (NASA SP-13)_	35
Lunary and Planetary Sciences in Space Exploration (NASA	
SP-14)	55
Celestial Mechanics and Space Flight Analysis (NASA SP-15)_	35
Data Acquisition from Spacecraft (NASA SP-16)	40
Control, Guidance and Navigation of Spacecraft (NASA SP-17)_	40
Chemical Rocket Propulsion (NASA SP-19)	40
Nuclear Rocket Propulsion (NASA SP-20)	45

	Cents
Power for Spacecraft (NASA SP-21)	25
Electric Propulsion for Spacecraft (NASA SP-22)	35
Aerodynamcs of Space Vehicles (NASA SP-23)	40
Gas Dynamics in Space Exploration (NASA SP-24)	40
Plasma Physics and Magnetohydrodynamics in Space Exploration (NASA SP-25)	50
Laboratory Techniques in Space Environment Research (NASA SP-26)	40
Materials for Space Operations (NASA SP-27)	
Structures for Space Operations (NASA SP-28)	35

Measurement of the Heartbeat of Bird Embryos with a Micrometeorite Transducer (NASA SP-5007).\*—Description of a device consisting of a pair of piezo-electric beams arranged to serve as springs and acceleration detectors, originally designed to serve as a detector of the impact of meteorites on spacecraft and satellites. 10 p. Clearinghouse, 50 cents.

Selected Welding Techniques, Part II (NASA SP-5009).\*—Outlines some of the more recent and interesting technological developments in welding. Welding tools and techniques described were selected from those used in welding aluminum sheet and plate at NASA's George C. Marshall Space Flight Center. 34 pp. GPO, 30 cents.

Effects of Low Temperatures on Structural Metals (NASA SP-5012).\*—Data developed by NASA's George C. Marshall Space Flight Center during inhouse and contractor research on the properties of materials at low temperatures. 55 pp. GPO, 40 cents.

Precision Tooling Techniques (NASA SP-5013).\*—A description of novel tooling techniques with possible industrial applications developed at NASA's George C. Marshall Space Flight Center. 25 pp. GPO, 25 cents.

Conference on New Technology (NASA SP-5015).\*—Proceedings of a conference on technology utilization held to discuss ways of transferring applicable space research knowledge to the industrial community. 156 pp. GPO, \$1.

Selected Welding Techniques (NASA SP-5003).—Descriptions and illustrations of tools and methods developed by NASA, and of potential value to industry, for welding aluminum sheet and plate. 25 pp. GPO, 30 cents.

Space Batteries (NASA SP-5004).—Descriptions of three sealed battery systems for spacecraft, including discussion of a mechanism of information exchange whereby current test data can be shared among space contractors. 53 pp. GPO, 25 cents.

The Measurement of Blood Pressure in the Human Body (NASA SP-5006).—A state-of-the-art summary prepared from the open literature for nonmedical scientists and engineers. 34 pp. GPO, 30 cents.

A subseries of special publications consist of data compilations and handbooks that present engineering and scientific information in conveniently useful forms for those working in specific fields, saving them time-consuming searches to assemble these data. Among these publications are:

Tables for Supersonic Flow Around Right Circular Cones at Small Angle of Attack (NASA SP-3007).\* 422 pp. GPO, \$2.25.

<sup>\*</sup> Released during this report period.

Tables of the Complex Fresnel Integral (NASA SP-3010).\* 294 pp. Clearinghouse, \$4.

Thermodynamic and Transport Properties for the Hydrogen-Oxygen System (NASA SP-3011).\* 419 pp. Clearinghouse, \$6.

Tables of Energy Losses and Ranges of Electrons and Positrons (NASA SP-3012).\* 128 pp. Clearinghouse, \$4.

Tables of Energy Losses and Ranges of Heavy Charged Particles (NASA SP-3013).\* 132 pp. Clearinghouse, \$4.

Thermodynamic Properties and Mollier Chart for Hydrogen from 300° K. to

20,000° K. (NASA SP-3002). 64 pp. Clearinghouse, \$1.75.

Tables for Supersonic Flow Around Right Creular Cones at Zero Angle of

Attack (NASA SP-3004). 422 pp. GPO, \$2.25.

Energy Spectra and Angular Distributions of Electrons Transmitted Through Sapphire (A1<sub>2</sub>O<sub>3</sub>) Foils (NASA SP-3008). 108 pp. Clearinghouse, \$2.50.

Tables of the Composition, Opacity, and Thermodynamic Properties of Hydrogen at High Temperatures (NASA SP-3005). 186 pp. Clearinghouse, \$3.

Tables of Flow Properties of Thermally Perfect Carbon Dioxide and Nitrogen Mixtures (NASA SP-3009). 114 pp. Clearinghouse, \$4.50.

<sup>\*</sup> Released during this report period.

## Appendix P

#### Major NASA Launches

(July 1-Dec. 31, 1964)

Name, date launched, mission	Vehicle	Site	Results
SERT-IA, July 20  Determine whether ion engines would operate in space.	Scout	WI 1	The 1½-kw. mercury electron bombardment thruster engine operated for a total of 30 minutes; first successful U.S. operation in space of an electric rocket engine. (The ½-kw. thruster falled to operate.)
Ranger VII, July 28 Lunar exploration by photography.	Atlas-Agena	ETR 1	Transmitted 4,316 high-quality photographs of the moon's surface—2,000 times clearer than any ever taken by the most powerful telescope. Impacted on Moon in Sea of Clouds 8 to 10 miles from aim point.
Syncom III, Aug. 19	Thrust-Aug- mented Thor- Delta.	ETR 1	First truly synchronous com- munications satellite. Tests successful. Telem- etry and communications equipment functioned as designed.
Explorer XX, Aug. 25 Study earth's upper ionosphere and gather data on electron densities and temperatures in vicinity of satellite.	Scout	WTR 1.	Used 6 fixed radio frequencies to determine height of iono- sphere above the earth and its ion composition. Orbit achieved; experiments transmitted as designed.
Nimbus I, Aug. 28  Orbit weather satellite constantly pointing at the earth to test day- and night-time cloud cover picture equipment and automatic picture transmission (APT) subsystem.	Thor-Agena	WTR 1_	All systems performed as designed until solar paddles locked and lost their ability to follow the sun.

Name, date launched, mission	Vehicle	Site	Results
Orbiting Geophysical Observatory (OGO-I), Sept. 4.  Through simultaneous readings of its 20 experiments produce integrated study of earth's magnetic field, radiation about the earth, and interaction of the two.	Atlas-Agena	ETR 1	Although highly experimental, has met its basic objectives.
Saturn I (SA-7), Sept. 18	Saturn I	ETR 1	Orbited unmanned Apollo "boilerplate" command, service modules attached to S-IV second stage. De- cayed September 22. Rough seas in Atlantic prevented recovery of camera package.
Explorer XXI, Oct. 3	Delta	ETR 1	Interplanetary Monitoring Platform (IMP) type of satellite. Still in orbit and transmitting.
Explorer XXII, Oct. 9  Study behavior and electron population of ionosphere; relate ionospheric behavior to solar radiation which produces ionization; determine geometry and distribution of ionospheric irregularities.	Scout	WTR 1_	Ionosphere beacon space- craft used laser tracking experiment for the first time. All of satellite's experiments transmitted as designed.
Mariner III, Nov. 5	Atlas-Agena	ETRI	Flight failed.
Explorer XXIII, Nov. 6	Scout	WI 1	Spacecraft succeeds Explorer XVI, launched Dec. 16, 1962, and is expanding data supplied by this earlier satellite.
Explorers XXIV and XXV, Nov. 21  Provide more detailed data on radiation-air density relationships in the upper atmosphere.	Scout	WTR 1	NASA's first dual launch. Explorer XXIV called Air Density Satellite; Explorer XXV, Injun Explorer B (AD/I-B). Explorer XXV was designed and built by the State University of lowa— the first satellite completely designed and built by a university.

Name, date launched, mission	Vehicle	Site	Results
Mariner IV, Nov. 28.  Flyby Mars and photograph the planet's surface and obtain atmospheric data by radio. Also measure solar plasma, magnetic fields, energetic particles, and cosmic dust near Mars and throughout 7½ months of flight.	Atlas-Agena	ETR 1	Successfully launched. Should flyby within 5,400 miles of Mars in mid-July. TV data to be transmitted back to earth through 150 million miles of space.
Apollo Flight Abort Test (ballistic) Little Joe II, Dec 8.  Demonstrate satisfactory performance of Apollo spacecraft launch escape system under conditions simulating catastrophic launch vehicle failure at altitude at which spacecraft is under maximum aerodynamic pressures. (Second of a series of unmanned ballistic flight tests.)	Little Joe II	WSR 1	Successful canard operation caused the command module to stabilize in the proper attitude to permit safe deployment of the earth-landing system parachutes. All major test objectives were met in the flight.
Atlas-Centaur (AC-4), Dec. 11	Atlas-Centaur	ETR 1	This fourth development flight was successful, but attempt at restarting the Centaur engine in flight failed.
San Marco I (Italian launching), Dec. 15  Provide measurements of air density by an original m ethod using two concentric spheres.	Scout	WI 1	First satellite built and instrumented in Western Europe; first satellite launching from U.S. by non-U.S. crew. Still in orbit, still transmitting.
Explorer XXVI, Dec. 21.  Study natural and artificial radiation belts surrounding the earth.	Thor-Delta	ETR 1	Fourth NASA energetic particles satellite (others were Explorers XII, XIV, and XV). Information gained should be of importance in design of spacecraft shielding and planning trajectories to the Moon. Still in orbit, still transmitting.

 <sup>&</sup>lt;sup>1</sup> ETR—Eastern Test Range, Cape Kennedy, Fla. WI—Wallops Island, Va.
 WSR—White Sands Missile Range, N. Mex.
 WTR—Western Test Range, Point Arguello, Calif.

### Appendix Q

#### NASA Launch Vehicles

		Payload ir	pounds		
Vehicle	Stages	345-mile orbit	Escape	Mars/ Venus	Principal use
Scout	4	150 to 220			Launching small scientific satellites and probes (Explorer, SERT, ion engine, San Marco I).
Delta	3	800	120		Launching scientific, meteorologi- cal, and communications satel- lites (TIROS, Orbiting Solar Observatory, OSO-I, Ariel, Tel- star I, Relay, Syncom II, Inter-
TAD (Thrust Augmented Delta).	3	1,000	150	120	planetary Monitoring Plaftorm (Explorer XXI), Energetic particles satellite (Explorer XXVI). Launching scientific, meteorological, communications, and bioscience satellites, and lunar and planetary probes. (Pioneer AD, TIROS K, TIROS operational satellites OT-3 and OT-2,
Thor-Agena B	2	1,600			Syncom III, Biosatellites C-F.) Launching scientific, communica- tions, and applications satellites (Echo II, Nimbus I, Polar Orbit- ing Geophysical Observatory).
TAT (Thrust Augmented Thor-Agena).	2	2,200			Launching geophysics and astronomy, and applications satellites (OGO-C, D, F, and Nimbus B).
Atlas-Agena B	21/2	5,000	750	400	Launching heavy scientific satel- lites, lunar and planetary probes (Ranger VII, Mariners III and IV, Orbiting Geophysical Observ- atory—O GO-I).
Atlas-Centaur	21/2	8,500	2, 300	1, 300	Launching heavy unmanned space- craft for lunar soft landers (Sur- yeyor).
Atlas D	1	(1)			Launched manned Mercury space- craft.
Titan II	. 2	7,000, 87/161 el-			Launching manned Gemini space
Saturn I	2	liptical orbit. 20,000 (15,000 without restart capability).			craft. Project Apollo.
Saturn IB		28,500			Do.
Saturn V	. 3	220,000	95,000	70,000	Do.

<sup>&</sup>lt;sup>1</sup> Only NASA application Project Mercury—2,500 pounds in 114-mile orbit.

# Appendix R

# NASA International Activities Summary

(Cumulative through Dec. 31, 1964)

						٠												
				Cool	Cooperative projects	projects	-			Operations support (tracking and data acquisition networks)	support	is support (tracking a acquisition networks)	and data s)		Pe	Personnel exchanges	xchange	
		Fli	Flight projects	ets	Gro	Ground-based projects for—	d project	s for—							Resi-			
	Location 1	Satel- lites	Experiments on NASA satellites	Sound- ing rockets	Mete- orolog- ical satel- lites	Com- muni- cations satel- lites	Iono- sphere beacon satel- lites	Iono- sphere sounding satellites	Scien- tific satel- lite	Manned flight	Deep	Opti- cal	Moon- watch	Data acqui- sition	<u> </u>	Inter- na- tional fellow- ships	Train- ing	Visits
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O U M M M	Cze" oslovakia Denmark Ecuador El Salvacor France	X	×	××	×× ××	××	×	х	×				XX X		××	×	××	XXXXX
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用公馬 17	Hungary Iceland India			×	×××	×	×					×		×	×		×	×××

See footnotes at end of table.

NASA International Activities Summary—Continued (Cumulative through Dec. 31, 1964)—Continued

			C00	Cooperative projects	projects				Operations support (tracking and data acquisition networks)	support squisition	(tracking network	and data	_	ă	srsonnel	Personnel exchanges	
	Ē	Flight projects	cts	Gro	Ground-based projects for—	d project	's for—							Resi-			
Location 1	Satel- lites	Experiments on NASA satellites	Sound- ing rockets	Mete- orolog- ical satel- lites	Com- muni- cations satel- lites	Iono- sphere beacon satel- lites	Iono- sphere sounding satellites	Scien- tific satel- lite	Manned flight	Deep space	Opti- cal	Moon- watch	Data scqui- sition	re- search asso- ciate- ships	Inter- na- tional fellow- ships	Train- ing	Visits
Indonesia				×										3			×
Iran			-	-			-				*	×		×	-		<b>4</b> ×
Ireland		-		∢×													×
Israel						×	1			-		×		××			××
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Japan			×	<b>*</b>	×	×	-				×	×	×	×	×	×	××
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Switzerland				×	-	×								₹	₹		4

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					4	Finland Liberia Rwandi Funisia,
		××		<b>x</b>	88	thiopia, Lebanon, graguay, rinidad,
					6	ubal, E Laos, J ama, Pe Syria, Th
					8	ablic, D Jordan, ua, Pan ietnam,
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×	1	×			27	iring independence international fellow sitor program only Cyprus, Dahomey
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Tanzania.	Turkey	United Kingdom.	U.S.S.R	ESRO 2	Total	Includ's separate jurisdicti and ESRO.  * European Space Research ( are inclusied under the countrie of The following, included in Afghanist an, Algeria, British

# Appendix S

#### Grants and Research Contracts Obligated <sup>1</sup>

(July 1-Dec. 31, 1964)	2	
Arizona:		*** ***
NsG-646 University of Arizona, G. A. Korn	N	<b>\$21</b> , 564
S 1 A Study of the Performance		
nization of Hybrid Computer Sys		
NsG-732 University of Arizona, W. G. TIFFT	and A. G. MEINEL	38, 576
A Study of Large Optical Te	elescope Systems for	
Manned Space Systems.		
NsG-733 University of Arizona, H. L. John	SON	19, 000
Seven-Color Photoelectric Ph	otometry of Bright	
Stars and Other Selected Objects.		
NsG(F)-25 University of Arizona, G. P. Kuip	ER	1, 200, 000
Construction of an Interdisc	ciplinary Space Sci-	
ences Center.		
NGR 03-003-003. Lowell Observatory, K. D. RAKOS.		15, 725
Research on the Measuremen	t of the Density of	•
the Martian Atmosphere.	t of the Bensity st	
Arkansas:		
NsG-713 University of Arkansas, M. K. Tes	ITEDM A N	104, 473
Investigation of the Application	otion of Insers to	202, 210
Instrumentation and Measuremen	at Techniques.	
California:	- D M Cours	59, 935
NsG-18 California Institute of Technology		00, 000
8 2 Investigation of Cylindrical ar		60, 000
NsG-172 California Institute of Technology,		60, 000
8 4 Investigation of Failure Crit		
Material Typical of Solid Rocket		040 000
NsG-426 California Institute of Technology,	R. LEIGHTON	840, 000
S 1 Research in Selected Field	s of Physics and	
Astronomy.		
NGR-05-002-028. California Institute of Technology	, W. A. FOWLER	90, 000
Study of Stellar Interiors and	d Nuclear Synthesis.	
NGR-05-002-031. California Institute of Technology	, F. STRUMWASSER	<b>126, 71</b> 3
Research in Neutral Control	of Hibernation in	
Mammals.		
NsG-170 University of California (Berkeley	7), N. PACE	20, 000
8 4 Experimental Studies of Hemo	dynamic and Related	
Physiological Functions in Prim	ates.	
NsG-170 University of California (Berkeley	7), N. PACE	100, 000
S 5 Experimental Studies of Hemo		
Physiological Functions in Prim		
NsG-274 University of California (Berkeley		28, 062
S 1 Investigation of Stresses and l		
Shells of Revolution.		
NsG-354 University of California (Berkeley	). E. POLAK	61, 372
S 2 Research in Control and Info	rmation Systems.	. , -
NsG-707 University of California (Berkeley	v) H WEAVER	69, 628
A Study of Advanced Infrared	Detectors for Use in	<b></b> -
Planetary Spectroscopy.	Detectors for one an	
NsG-479 University of California (Berkeley	A H JONES	459, 939
S 1 Research in the Chemistry of I		-00, 500
5.4 nescaren in the Chemistry of 1	241 DJ 040	

(July 1-Dec. 31, 1964) 2—Continued

NGR-05-003- <b>068.</b>	University of California (Berkeley) S. MABGEN Clinical Nutritional Study of Minimal Protein and Caloric Requirements.	\$120, 415
NGR-05-003- 080.	University of California (Berkeley) R. Colwell  Multispectral Photographic Experiments Based on a Statistical Analysis of Spectrometric Data.	48, 257
NGR-05-003- 089.	University of California (Berkeley) D. H. Calloway Investigation of the Nutritional Properties of Hydrogenomonous Eutropha.	18, 241
NsG-656	University of California (Davis) J. L. INGRAHAM Study of Theoretical Lower Limits of Temperature for Bacterial Growth.	21, 227
NsG-216 S 1	University of California (Los Angeles) G. J. F. MacDonald.  Theoretical Investigation of the Constitution of the Moon and Planets.	140, 604
NsG-237 S 3	University of California (Los Angeles) W. F. LIBBY, J. D. French. Multidisciplinary Research in Space-Related Science and Technology.	821, 000
NsG-237 S 4	University of California (Los Angeles) W. F. Libby, J. D. French. Multidisciplinary Research in Space-Related Science and Technology.	234, 000
NsG-313 S 1	University of California (Los Angeles) G. W. WETHERILL.  Isotopic Chemistry of Meteorites, Including Studies of Variation in Isotopic Abundance Among Discrete Specimens.	50, 000
NsG-314 S 1	University of California (Los Angeles) G. C. KENNEDY- High Pressure Study of the Solid Phases of Inert Gases.	<b>53, 08</b> 8
NGR-05-007- 041.	University of California (Los Angeles) Z. Sekera Feasibility Studies of Coordinated Radiation Ex- periments from Meteorological Satellites.	74, 379
NGR-05-007- 047.	University of California (Los Angeles) S. SONENBLUM A Study of Methods for the Analysis and Utiliza- tion of NASA Generated Data.	94, 174
NASr-241	University of California (Los Angeles) J. D. French To Conduct a Summer Institute in Space Biology.	29, 925
NsG-317 S 1	University of California (San Diego) G. ARRHENIUS Investigation of Composition and Structure of Meteorities.	84, 024
NsG-319 S 2	University of California (San Diego) G. G. Goles Geochemistry of Trace Elements in Meteorites.	60, 000
NsG-321 S 2	University of California (San Diego) J. R. Arnold Research on Meteorites and Cosmic Rays.	50, 766
	University of California (San Diego) H. E. Suess An Investigation of the Cosmic Abundances of the Elements.	68, 467
NsG-541 S 1	University of California (San Diego) H. C. URBY Analysis of the Organic and Inorganic Constituents of Carbonaceous and Other Selected Stoney Meteorites.	94, 000
NsG-731	University of California (San Diego) J. R. Arnold Collection of Cosmic Dust in the Stratosphere.	95, 129
NASr-116 A 5	University of California (San Diego) C. McIlwain Reduction of Radiation Data from the SUI Experi- ments on the Relay Satellite	52, 000
NASr-21(04) A 3	Rand Corporation, G. F. SCHILLING Studies to Derive a Consistent Set of Fundamental Constants and Prepare Tables of the Values of Constants.	5, ὑῦῦ

(July 1-Dec. 31, 1964) 2—Continued

(6 wiy 1-1500. 61, 1504) Continued	
	-400
University of Southern California, R. SHIMKA Research on Glass Transition Phenomena.	<b>\$45</b> , 780
University of Southern California, G. L. Weissler  Measurement of Absolute Photon Flux Using a Superconducting Bolometer.	38, 900
University of Southern California, J. MEEHAN Construction and Renovation of the Human Centri-	160, 000
Stanford Research Institute, T. L. SMITH	43, 676
Stanford Research Institute, D. L. CHAMBERLAIN  A Study of Bonding Between Glass and Plastics.	<b>32, 46</b> 8
Stanford Research Institute, M. GOLUBStudy of Photo-Isomerization of Polybutadiene by Vacuum Ultraviolet Radiation.	9, 954
Stanford University, F. MORRELL Study of Physiological Mechanisms Involved in the Adaptation of Humans to Monotonous Environments.	99, 658
Stanford University, O. BUNEMANStudy of Randomization of Electron Energy in Plasma Thermionic Diodes.	36, 000
Stanford University, R. H. CANNON Development of a Zero-G Drag Free Satellite.	88, 950
Stanford University, V. R. ESHLEMAN Participation in the Telemetry Occultation Experi-	34, 102
Stanford University, W. R. RAMBO	45, 660
Stanford University, O. K. GARRIOTT	38, 600
Research to Obtain Information About the Electron Content in the Ionosphere and its Variation.	
U.S. Naval Radiological Def. Lab., A. REETZAnalysis of Electron Scattering Data.	33, 000
	00.074
University of Colorado, J. R. LITTLE	29, 374
University of Colorado, W. A. RENSELaboratory Investigations of Ultraviolet Reflectivity of Mirror Materials.	130, 000
U.S. National Bureau of Standards, R. B. Scott Study of Solar-Geophysical Activity.	94, 000
U.S. National Bureau of Standards, J. W. WRIGHT Ionospheric Soundings on Board a Planned Voyage	25, 000
Univ. Corp. for Atmospheric Research, L. HOUSE Research in Laboratory Vacuum Ultraviolet	75, 000
Univ. Corp. for Atmospheric Research, F. W. ROECKER- Balloon, Helium, and Field Services for Two Launchings of Low Energy Gamma-ray Astronomy	74, 000
Univ. Corp. for Atmospheric Research, W. O. ROBERTS.	208, 000
Western State College of Colorado, T. D. VIOLETTAnalysis of Rocket Spectroscopy of a Region of the Solar Ultraviolet Spectrum.	40, 232
	University of Southern California, R. SHIMKA

(July 1-Dec. 31, 1964) 2—Continued

Connecticut:		
Connecticut.		
NsG-309	University of Connecticut, D. P. LINDORFF	\$22,500
S 2	Analytical and Experimental Research of Control	,==, •••
	Systems to Parameter Variations.	
NsG-192	Yale University, S. R. Lipsky	126, 500
S 2	Research on Gas Chromatographic Systems to	120, 000
	Analyze Certain Chemical Constituents of the Sur-	
	face of the Moon.	
NsG-374	Yale University, R. GALAMBOS	40 OOF
81	Electrophysiological Studies of the Brain Includ-	66, 995
51	ing Improvement of Typesin and I Marketing	
	ing Improvement of Experimental Techniques and	
NOD OF COA	Methodology.	
NGR-07-004-	Yale University, R. WILDT and V. SZEBEHELY	24, 499
029.	Theoretical Research in Stellar and Planetary	
	Astrophysics.	
Delaware:		
NsG-356	University of Delaware, J. HARTNETT	40, 200
S 1	Research in Mass Transfer Cooling in Nitrogen and	•
	Carbon Dioxide Gas Streams.	
District of Columbia:		
	American University, R. T. FOLEY	100, 000
11 day 00 000 000.	Investigation of Plantachemistry of High Engage	100, 000
	Investigation of Electrochemistry of High Energy	
70 00 000 001	Compounds in Organic Electrolytes.	
	Atomic Energy Commission, A. R. LUEDECKE	<b>35, 200</b>
A 1	Develoment of A Prototype Neutron Source for	
	Space Exploration.	
R-09-019-014	Atomic Energy Commission, A. R. LUEDECKE	40,000
	Development of A Neutron Source to Fit Certain	
	NASA Requirements for Space-Related Measure-	
	ments.	
R-104(04)	Atomic Energy Commission, M. A. Bender	185 000
A 1	Gemini-III Human Blood Irradiation Experiment.	155, 000
	Atomic Engage Commission I A Warner	0.000
N-145	Atomic Energy Commission, J. A. WHEELER	3, 000
	Conference on Diffusion in Body-Centered Cubic	
	Materials.	
Ng(+417		
1100 111	Catholic University of America, C. C. CHANG	30, 000
8 1	Theoretical Research of the Origin of Van Allen	30, 000
S 1	Theoretical Research of the Origin of Van Allen Radiation Belts and the Interaction of the Solar	30, 000
8 1	Theoretical Research of the Origin of Van Allen	30, 000
S 1	Theoretical Research of the Origin of Van Allen Radiation Belts and the Interaction of the Solar Wind.	ŕ
S 1	Theoretical Research of the Origin of Van Allen Radiation Belts and the Interaction of the Solar Wind. George Washington University, V. Rock	30, 000
S 1	Theoretical Research of the Origin of Van Allen Radiation Belts and the Interaction of the Solar Wind. George Washington University, V. Rock The Establishment of a Program of Policy Studies	ŕ
S 1	Theoretical Research of the Origin of Van Allen Radiation Belts and the Interaction of the Solar Wind.  George Washington University, V. Rock The Establishment of a Program of Policy Studies in Science and Technology.	100, 000
NsG-727 NsG-428	Theoretical Research of the Origin of Van Allen Raddation Belts and the Interaction of the Solar Wind.  George Washington University, V. Rock The Establishment of a Program of Policy Studies in Science and Technology.  Georgetown University, W. J. THALER	ŕ
NsG-727 NsG-428 S 2	Theoretical Research of the Origin of Van Allen Raddation Belts and the Interaction of the Solar Wind.  George Washington University, V. Rock The Establishment of a Program of Policy Studies in Science and Technology.  Georgetown University, W. J. THALER Research in Thermal Equilibrium of Spacecraft.	100, 000 25, 000
NsG-727 NsG-428 S 2 NGR-09-009-	Theoretical Research of the Origin of Van Allen Radiation Belts and the Interaction of the Solar Wind.  George Washington University, V. Rock The Establishment of a Program of Policy Studies in Science and Technology.  Georgetown University, W. J. THALER Research in Thermal Equilibrium of Spacecraft.  Georgetown University, J. H. SEIPEL	100, 000
NsG-727 NsG-428 S 2	Theoretical Research of the Origin of Van Allen Radiation Belts and the Interaction of the Solar Wind.  George Washington University, V. Rock	100, 000 25, 000
NsG-727 NsG-428 S 2 NGR-09-009- 005.	Theoretical Research of the Origin of Van Allen Radiation Belts and the Interaction of the Solar Wind.  George Washington University, V. Rock The Establishment of a Program of Policy Studies in Science and Technology.  Georgetown University, W. J. THALER Research in Thermal Equilibrium of Spacecraft.  Georgetown University, J. H. SEIPEL Research in the Magnetic Field Component of the Neural Impulse.	100, 000 25, 000
NsG-727 NsG-428 S 2 NGR-09-009- 005.	Theoretical Research of the Origin of Van Allen Radiation Belts and the Interaction of the Solar Wind.  George Washington University, V. Rock	100, 000 25, 000
NsG-727 NsG-428 S 2 NGR-09-009- 005.	Theoretical Research of the Origin of Van Allen Radiation Belts and the Interaction of the Solar Wind.  George Washington University, V. Rock The Establishment of a Program of Policy Studies in Science and Technology.  Georgetown University, W. J. THALER Research in Thermal Equilibrium of Spacecraft.  Georgetown University, J. H. SEIPEL Research in the Magnetic Field Component of the Neural Impulse.	100, 000 25, 000 24, 408
NsG-727 NsG-428 S 2 NGR-09-009- 005.	Theoretical Research of the Origin of Van Allen Radiation Belts and the Interaction of the Solar Wind.  George Washington University, V. Rock The Establishment of a Program of Policy Studies in Science and Technology.  Georgetown University, W. J. THALER Research in Thermal Equilibrium of Spacecraft.  Georgetown University, J. H. SEIPEL Research in the Magnetic Field Component of the Neural Impulse.  National Academy of Sciences, F. CAMPBELL Support of Second General Assembly of the Inter-	100, 000 25, 000 24, 408
NsG-727 NsG-428 S 2 NGR-09-009- 005.	Theoretical Research of the Origin of Van Allen Radiation Belts and the Interaction of the Solar Wind.  George Washington University, V. Rock The Establishment of a Program of Policy Studies in Science and Technology.  Georgetown University, W. J. THALER Research in Thermal Equilibrium of Spacecraft.  Georgetown University, J. H. SEIPEL Research in the Magnetic Field Component of the Neural Impulse.  National Academy of Sciences, F. Campbell	100, 000 25, 000 24, 408
NsG-727 NsG-428 S 2 NGR-09-009- 005.	Theoretical Research of the Origin of Van Allen Radiation Belts and the Interaction of the Solar Wind.  George Washington University, V. Rock	100, 000 25, 000 24, 408 6, 000
NsG-727 NsG-428 S 2 NGR-09-009- 005. NsG-638	Theoretical Research of the Origin of Van Allen Radiation Belts and the Interaction of the Solar Wind.  George Washington University, V. Rock The Establishment of a Program of Policy Studies in Science and Technology.  Georgetown University, W. J. THALER Research in Thermal Equilibrium of Spacecraft.  Georgetown University, J. H. Seipel Research in the Magnetic Field Component of the Neural Impulse.  National Academy of Sciences, F. Campbell Support of Second General Assembly of the International Organization for Pure and Applied Biophysics.  National Academy of Sciences, W. H. Bailey	100, 000 25, 000 24, 408
NsG-727 NsG-428 S 2 NGR-09-009- 005. NsG-638	Theoretical Research of the Origin of Van Allen Radiation Belts and the Interaction of the Solar Wind.  George Washington University, V. Rock The Establishment of a Program of Policy Studies in Science and Technology.  Georgetown University, W. J. THALER Research in Thermal Equilibrium of Spacecraft.  Georgetown University, J. H. SEIPEL Research in the Magnetic Field Component of the Neural Impulse.  National Academy of Sciences, F. CAMPBELL Support of Second General Assembly of the International Organization for Pure and Applied Biophysics.  National Academy of Sciences, W. H. BAILEY Support of a Committee on Remote Sensing of	100, 000 25, 000 24, 408 6, 000
NsG-727 NsG-428 S 2 NGR-09-009- 005. NsG-638 NGR-09-012- 020.	Theoretical Research of the Origin of Van Allen Radiation Belts and the Interaction of the Solar Wind.  George Washington University, V. Rock The Establishment of a Program of Policy Studies in Science and Technology.  Georgetown University, W. J. THALER Research in Thermal Equilibrium of Spacecraft.  Georgetown University, J. H. Seipel Research in the Magnetic Field Component of the Neural Impulse.  National Academy of Sciences, F. Campbell Support of Second General Assembly of the International Organization for Pure and Applied Biophysics.  National Academy of Sciences, W. H. Bailey Support of a Committee on Remote Sensing of Environment.	100, 000 25, 000 24, 408 6, 000
NsG-727 NsG-428 S 2 NGR-09-009- 005. NsG-638 NGR-09-012- 020. NASr-62	Theoretical Research of the Origin of Van Allen Radiation Belts and the Interaction of the Solar Wind.  George Washington University, V. Rock The Establishment of a Program of Policy Studies in Science and Technology. Georgetown University, W. J. THALER Research in Thermal Equilibrium of Spacecraft. Georgetown University, J. H. Seipel Research in the Magnetic Field Component of the Neural Impulse. National Academy of Sciences, F. Campbell Support of Second General Assembly of the International Organization for Pure and Applied Biophysics. National Academy of Sciences, W. H. Bailey Support of a Committee on Remote Sensing of Environment. National Academy of Sciences, S. S. Steinberg	100, 000 25, 000 24, 408 6, 000
NsG-727 NsG-428 S 2 NGR-09-009- 005. NsG-638 NGR-09-012- 020.	Theoretical Research of the Origin of Van Allen Radiation Belts and the Interaction of the Solar Wind.  George Washington University, V. Rock	100, 000 25, 000 24, 408 6, 000
NsG-727 NsG-428 S 2 NGR-09-009- 005. NsG-638 NGR-09-012- 020. NASr-62 A 3	Theoretical Research of the Origin of Van Allen Radiation Belts and the Interaction of the Solar Wind.  George Washington University, V. Rock	100, 000 25, 000 24, 408 6, 000 10, 000 94, 000
NsG-727	Theoretical Research of the Origin of Van Allen Radiation Belts and the Interaction of the Solar Wind.  George Washington University, V. Rock	100, 000 25, 000 24, 408 6, 000
NsG-727 NsG-428 S 2 NGR-09-009- 005. NsG-638 NGR-09-012- 020. NASr-62 A 3	Theoretical Research of the Origin of Van Allen Radiation Belts and the Interaction of the Solar Wind.  George Washington University, V. Rock	100, 000 25, 000 24, 408 6, 000 10, 000 94, 000
NsG-727 NsG-428 S 2 NGR-09-009- 005. NsG-638 NGR-09-012- 020. NASr-62 A 3 NSR-09-012- 901.	Theoretical Research of the Origin of Van Allen Radiation Belts and the Interaction of the Solar Wind.  George Washington University, V. Rock	100, 000 25, 000 24, 408 6, 000 10, 000 94, 000
NsG-727 NsG-428 S 2 NGR-09-009- 005. NsG-638 NGR-09-012- 020. NASr-62 A 3 NSR-09-012- 901. NSR-09-012-	Theoretical Research of the Origin of Van Allen Radiation Belts and the Interaction of the Solar Wind.  George Washington University, V. Rock	100, 000 25, 000 24, 408 6, 000 10, 000 94, 000
NsG-727 NsG-428 S 2 NGR-09-009- 005. NsG-638 NGR-09-012- 020. NASr-62 A 3 NSR-09-012- 901.	Theoretical Research of the Origin of Van Allen Radiation Belts and the Interaction of the Solar Wind.  George Washington University, V. Rock	100, 000 25, 000 24, 408 6, 000 10, 000 94, 000
NsG-727 NsG-428 S 2 NGR-09-009- 005. NsG-638 NGR-09-012- 020. NASr-62 A 3 NSR-09-012- 901. NSR-09-012-	Theoretical Research of the Origin of Van Allen Radiation Belts and the Interaction of the Solar Wind.  George Washington University, V. Rock	100, 000 25, 000 24, 408 6, 000 10, 000 94, 000

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	velopment of Improved Method for Measure- of Spectral Irradiance from Solar Simulators.	
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R-09-022-030 Nations Ex	tl Bureau of Standards, J. T. JEFFERIES perimental Investigation of Chromospheric and nal Phenomena during a Solar Eclipse.	24, 000
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	Partment of Interior, E. SHOEMAKER ological Training Program for Astronauts.	150, 000
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A 1 Ab	stracting 1964 Literature.	
A 3 Su	LVy—Office of Naval Research, G. C. TOLHURST— pport of National Academy of Sciences, Armed es Committees on Vision and Hearing and Bio- tities.	22, 500
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	vy-Office of Naval Research Operation of the	38, 200
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	nduct Studies of Auditory Information Proc-	10, 000
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R-147 U.S. Na	aval Research Laboratory, G. C. HICKSeteor Astronomy Studies Based on TV Cinema-	100, 000
Florida :	EA .	
NGR-10-004- Florida 018. Ph	State University, H. GAFFRONotochemical Transformation of Acetate into Cell Material.	28, 080

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013.	University of Miami, M. L. HARVEY	81, 432
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R-10-009-013	Naval School of Aviation Medicine, A. Graybiel	3 <b>24, 214</b>
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NsG-258 S 1	Georgia Institute of Technology, W. K. RIVERS, JR Study of Interference Spectrometry.	46, 920
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S 2	Heat Transfer to a Gas Containing a Cloud of Particles.	
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010.	University of Hawaii, T. A. ROGERSStudy of Body Fluid Volume and Electrolyte Derangements in Fasting.	16, 825
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	University of Hawaii, H. D. McAllister.  Research to Design, Construct and Test a Prototype of a High Speed, High Resolution Rocket Echelle Solar Spectrograph.	59, 587
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NSR-14-041- 001.	American Bar Foundation, S. H. Lay	80, 000
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8 4	A Theoretical Investigation of Further Consequences of the Solar Wind.	00, 120
	University of Chicago, J. A. SIMPSON Mariner C and D Data Analysis.	51, 384
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NsG(F)-26	University of Illinois, D. ALPERT	1, 125, 000
NGR-14-005- 037.	University of Illinois, L. GOLDSTEINInvestigation of the Basic Processes Occurring in Gaseous Plasma in Various Charge Density and Energy States.	40, 000
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	University of Kansas, J. S. McNown	100, 000
S 2	Interdisciplinary Studies in Space Sciences and Technology.	200, 000
NaC-477	University of Kansas, R. K. Moore	40, 920
8 1	A Study of Earth Returns from Topside Ionosphere Sounders.	,
NsG-575	University of Kansas, G. G. WISEMAN	17, 000
S 1	Investigation of Electrocaloric Effects in Ferro- electric Substances.	
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S 1	Studies in the Learning and Memory of Skilled Performance.	
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NGR-18-002- 005.	University of Louisville, R. H. WILEYStudies in Space-Related Polymer and Bio-Organic Chemistry.	127, 542
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NGR-21-002 022.	University of Maryland, C. O. ALLEYStudy of the Physics of Laser Radiation.	120, 000
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R-38A 3	U.S. Naval Medical Research Institute, T. H. Ben- zinger. Research into Basic Physiological Mechanisms which Defend the Human Body Against Heat and Cold.	50, 000
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8 2	Harvard University, W. H. Sweet  Interdisciplinary Studies of the Effects of High Energy Protons on Biologic Systems.	120, 800
8 1	Harvard University, F. L. WHIPPLE  A Theoretical Study of Meteoric Trajectories and Processes Including Examination of the Incidence and Characteristics of Photographic Meteors.	25, 000
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S 1	RINGTON	1, 505, 000
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8 1	and Y. T. LI.	36, 000
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NsG-659	University of Michigan, T. D. Goddard  A Theoretical Study of the Rheology of Disperse Fluid Systems.	19, 440
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A 4	Sounding Rockets Studies of the Upper Atmosphere.	, ~~
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8 1	Ney.	
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8 4	Washington University, J. KLARMANNElectronic Techniques in the Investigation of the Cosmic Radiation.	80, 000
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NsG(F)-23	New York University, A. FERRI	582, 000
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NsG-324 Penr S 2	nsylvania State University, E. C. POLLARD	171, 960
023.	nsylvania State University, J. L. SHEARER Research and Development of Onboard Systems and Elements for Aerospace Vehicles.	39, 393

(July 1-Dec. 31, 1964) 2—Continued

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NsG-416	University of Pittsburgh, D. HALLIDAY	\$250,000
S 1	Interdisciplinary Space-related Research in the	
	Physical, Life and Engineering Sciences.	
NASr-179	University of Pittsburgh, M. DONAHUE	200, 000
	Helium Geocorona Measurements.	
	U.S. Navy—Naval Air Engineering Center, G. L.	
A 1	SANWALD	<b>167, 460</b>
	Turbine Disk Burst Protection Study.	
Rhode Island:	Day of Water olds D. O. Dayson	<b>=</b>
	Brown University, D. C. DRUCKER	5, 402
S 1	Theoretical Analysis of the Fragmenting Tube-	
NCP 40 000	Energy Absorption Process.	<b>71</b> 000
NGR-40-002- 015.	Brown University, J. P. LASALLE	51, 286
Tennessee :	Research on Nonlinear Dynamical Systems.	
	University of Tennessee, J. D. Hung.	0E 000
8 2	Research in the Area of Control Systems Theory.	25, 000
Texas:	nesearch in the Area of Control Systems Incory.	
	Baylor University, V. Collins	5, 000
	Blood Volume Determinations and Associated	0, 000
	Chemistries and Physiologic Studies in Athletes	
	Under Stress.	
NASr-198		129, 935
A 2	McCracken.	,
	Development Program in the Study of Cosmic Ray	
	Phenomena.	
NSR-44-004-017.	Graduate Research Center of the SoWest, J. A. FEJER	265, 255
	Comparison of rocket-borne probes for electron den-	•
	sity measurements.	
	Rice University, B. J. O'BRIEN-	200, 000
A 2	Rocket-borne studies of particle fluxes in Auroras.	
	University of Texas, B. D. TAPLEY	10, 050
S 1	Study of Low-Thrust Guidance Methods.	
	University of Texas, E. L. SCHUCKING	5, 000
028.	Partial Support for the International Symposium	
000 DATE	on High Energy Astronomy.	
NASI-230	University of Texas, H. J. SMITH	113, 540
	Modifications to McDonald Observatory 82-inch	
NAS- 949	telescope Coude spectrograph for planetary observing.	
NASI-242	University of Texas, H. J. SMITH	700, 000
	Construction and operation of NASA McDonald 84-inch planetary astronomy telescope facility.	
Virginia :	ox-men planetary astronomy telescope facility.	
<b></b>	Medical College of Virginia, F. T. O'FOGHLUDHA	49, 606
004.	Measurement of Total Energy Absorption in Omni-	48, 000
	directional Photon and Particle Fluxes.	
R-47-009-001	Department of the Army (Corps of Engineers)	31, 320
	Study of the Development and Proclamation of a	02, 020
	"NASA Earth Atlas".	
R-47-009-002	Department of the Army (Corps of Engineers)	33, 000
	Study of Feasibility of Objective Color Sensors.	,
R-47-009-002	Department of the Army (Corps of Engineers)	160,000
	Study to Design and Install a Calibration Test	
	Area for Improved Understanding of Radar Inter-	
D 45 600 000	actions with Soil Rock.	
K-47-009-004	Department of the Army (Corps of Engineers)	49, 800
	Investigation of Geoscience Data Extraction from	
	Radar Imagery.	

(July 1-Dec. 31, 1964) 2-Continued

	(5 , 5 , 7 , 7	
Virginia-Continued		
	Department of the Army (Corps of Engineers) In-situ Reflectance Studies of Rock and Soils for Manned Space Science Test-Sites.	<b>\$10, 200</b>
NsG-340 1 S 1	University of Virginia, R. L. RAMBY  A Study of Thin Film Vacuum Deposited Junctions.	39, 590
NGR-47-005- U 022.	Jniversity of Virginia, J. W. BEAMSInvestigation to Increase the Accuracy of Newtonian Gravitational Constant, G.	99, 884
Washington:		
NsG-401 U S 2	University of Washington, R. BOLLARDAnalytical & Experimental Study, Using Photoelastic methods to Establish a Procedure for Stress Analysis of a Voscoelastic Metal.	41, 847
NsG-590 1	University of Washington, N. SATHERStudy of Molecular Theory of Non-Newtonian Fluids.	18, 000
NGR-48-002- U 010.	University of Washington, R. G. JOPPA Experimental & Theoretical Investigation of Wind Tunnel Geometry, Emphasizing Factors Pertinent to V/STOL Vehicle Testing.	46, 266
Wisconsin:		
NASr-143 A 2	Astronautics Corp. of America, R. SEINFELD Stable Platform Equipment for the X-15 Ultraviolet Photography Experiments.	89, 862
NsG-275 I S 2	University of Wisconsin, J. O. Hirschfelder	400, 000
Nasw-65 U A 10	University of Wisconsin, V. E. SUOMI	196, 000
Foreign:		
S 4	University of Auckland, H. A. WHALEInvestigation of Signals from Artificial Satellites.	23, 000
NASr-140 1 A 2	McGill University, J. BIRD	5, 000
NASr-140 I A 3	McGill University, J. Bird	27, 810
NGR-52-039- 1 002.	University of Queensland, H. C. Webster  A Study of the Geographical Distribution of Geomagnetic Micropulsations.	4, 650
NGR-52-026- 1 008.	University of Toronto, G. K. Korbacher	18, <b>4</b> 39

<sup>&</sup>lt;sup>1</sup> The grants listed in this appendix are reported to the Congress in compliance with the requirements of the grants statute, 42 U.S.C. 1891-93 (72 Stat. 1793).

<sup>&</sup>lt;sup>2</sup> Contracts have prefix NAS or NSR; Grants have prefix NsG or NGR; transfer of funds to Government agencies have prefix R. Earlier grants and contracts ae listed in appendices of previous NASA Semiannual Reports to Congress.

#### Appendix T

#### Institutions Currently Participating in NASA's Predoctoral Training Program

(Dec. 31 1964)

\*Adelphi University Alabama, University of \*Alaska, University of \*Alfred University Arizona State University Arizona, University of Arkansas, University of Auburn University \*Boston College \*Boston University \*Brandeis University \*Brigham Young University Brooklyn, Polytechnic Institute of \*Brown University California Institute of Technology \*California, University of, Berkeley California, University of, Los Angeles \*California, University of, Riverside \*California, University of, San Diego Carnegie Institute of Technology Case Institute of Technology Catholic University of America Chicago, University of

Clemson University

\*Colorado School of Mines
Colorado State University
Colorado, University of
Columbia University
Connecticut, University of
Cornell University

\*Dartmouth College
Delaware, University of

\*Clarkson College of Technology

Cincinnati, University of

\*Clark University

Denver, University of Duke University \*Emory University Florida State University Florida, University of \*Fordham University

George Washington University

\*Georgetown University Georgia Institute of Technology

\*Georgia, University of

\*Hawaii, University of Houston, University of

Howard, University
 Illinois Institute of Technology
 Illinois, University of
 Indiana University

Iowa, State University of Iowa State University Johns Hopkins University

Kansas State University Kansas, University of Kent State University

\*Kentucky, University of Lehigh University Louisiana State University

\*Maine, University of Maryland, University of

Massachusetts Institute of Technology

 Miami, University of Michigan State University Michigan, University of Minnesota, University of
 Mississippi State University

\*Mississippi, University of Missouri, University of Missouri School of Mines and Metallurgy

\*Montana State College \*Montana State University

\*Nebraska, University of Nevada, University of

\*New Hampshire, University of

\*New Mexico State University New Mexico, University of

\*New York, The City University of

\*New York, State University of, Stony Brook New York University

New York University
North Carolina State College
North Carolina, University of
\*North Dakota State University

Northeastern University Northwestern University Notre Dame, University of Ohio State University

\*Ohio University

<sup>\*</sup>Institutions entering the program in Fiscal Year 1964.

# Institution Currently Participating in NASA's Predoctoral Training Program—Continued

#### (Dec. 31, 1964)—Continued

Oklahoma State University
Oklahoma, University of
Oregon State University
Pennsylvania State University
Pennsylvania University
Pennsylvania University of
Pittsburgh, University of
Princeton University
Purdue University
Rensselaer Polytechnic Institute
Rhode Island, University of
Rice University
Rochester, University of

\*Rutgers, The State University Saint Louis University \*South Carolina, University of Southern California, University of

\*Southern Methodist University Stanford University Stevens Institute of Technology Syracuse University Tennessee, University of

Texas A&M University \*Texas Christian University Texas Technological College Texas, University of \*Toledo, University of \*Tufts University Tulane University Utah State University Utah, University of Vanderbilt University Vermont, University of Virginia Polytechnic Institute Virginia, University of \*Washington State University Washington University (St. Louis) Washington, University of (Seattle)

\*Wayne State University West Virginia University Western Reserve University Wisconsin, University of Yale University

<sup>\*</sup>Institutions entering the program in Fiscal Year 1964.